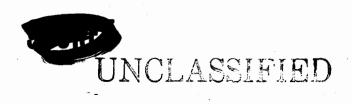


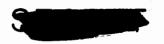
Edited by Wilma J. Bunker, Group S-4 Prepared by Petrita (Pat) Montano, Group S-4

NOTICE: Reproduction of this document requires the written consent of the originator, his successor, or higher authority.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

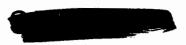




CONTENTS

GLUSSARY	• • • • •,	• • •	• •	• •	• •	•	• •	•	• •	•	•	• •	•	•	•	•	•	•	•	•	•
EXECUTIVE	SUMMARY		•					•	•		• .	• •									. 1
ABSTRACT								•		•	•	• .		•						•	. 2
CHAPTER I	. INTRODU	JCTION	• •					•			•		•			•	•			•	. 2
Α.			• •															•	•	• (. 2
В.																					
С.																					
D.	Definitio	on of T	erms	•	• •		•	•	•	•	•	•	•	•	•	•	• ,	•	•	•	. 2
CHAPTER I	I. REVIEW	OF PR	EVIO	JS S	TUD	ES	ANI) SE	R۷	ICE	RE	QU	IRE	ME	NT	Ś		•			. 2
Α.	General																		• ,		. 2
В.		of Spe	cific	: St	udie	es .	•		•	•			•	•	•	•	•	•	•		. 2
С.	Summary o	of Serv	rice I	≀equ	iren	nent	s.		•	•		•	•	•	•	• ,	•	•	• (4
CHAPTER I	II. REVIE	W OF M	IODUL#	AR T	ECHN	10 L0	GΥ		•				•	•	•	•		•	• •		. 4
Α.	General																				
В.	Presealed	l-Pit W	leapor	15			•.			•			• -		•			• •			4
С.	Benefits																				
D.	Disadvant																				
Ε.	Sealed-Pi	t Tech	nolog	IJ			•		•	•		•	•	•	•	•	•				4
F.	Current C																				
G.	INC/Conve	rtible	Wart	iead	0bs	erv	ati	ons	•	•		•	•	•	•	•	•	•	• •	•	5
CHAPTER IN	. POTENT	IAL AP	PLICA	TIO	NS C	F M	ODU	ILAR	TE	ЕСН	NOL	.OG1	ſ	•	•						5
Α.	General			•																	5
В.	Approach						. •		•			•	•					•, (54
С.	Assessmen	t		•			•		•	•		•	•	•	•	•	•	• •		•	60
CHAPTER V	UTILITY	ANALY	SIS .	•			•	•				•,	•			•	•	•			64
Α.	Introduct												•			•	. ,				64
В.	Weapon De	script	ion a	na .	Stoc	крі	re-	to-	Lau	Inc	n										-
•	Sequence																			•	66
С.	Approach	• • •	• • •	•	• •	• •	•	• •	•	•	• •	•	•	•	•	•	• •	• •	•	•	76
<u>D</u> .	Safety .	• • •	• • •	•	• •	• •	•	• •	•	•	• •	•	•	•	•	•	•		•	•	78
Ę.	Security																			•	80
F.	Survivabi	11 ty		•	• •	• •	•	• •	•	•	• •	•	•	•	•	•	• •	•	•	•	84
G.	Operation																		•	•	89
	Logistics														•	•		•	•	•	97
	Costs .	• • •		•	• •	• •	•	• •	•	•	• •	•	•	•	•	•	• •	•	•	•	105
J.	Summary Me	erit Al	naıys	es .	• •		•		•	•		•	•	•	•	•			•	•	111





VI.	REV	EW OF PERTINENT REGULATIONS AND DIRECTIVES
		General
		Effect of Present Directives
	С.	Expectation for Change in Handling Procedures 116
VII.	CON	LUSIONS AND RECOMMENDATIONS
	Α.	Summary
	в.	-indings
	C.	Recommendations
REFER	ENCE	



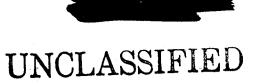


TABLES

	II-I.	Trade-off Evaluations	38
	V-I.	Comparison of Army Baseline and Modular Candidates	71
	V-II.	Comparison of Navy Baseline and Modular Candidates	74
	V-III.	Comparison of Air Force Baseline and Modular Candidates	76
±•		FIGURES	•
	III-1.	Mk 15 strategic bomb	43
	III-2.	Mk 33 8-in. projectile	44
	III-3.	Los Alamos Harpoon Proposal 3A warhead	48
doc	III-4.	• • • • • • • • • • • • • • • • • • • •	49 DOE
	III-5.		50 (0) (3
i	III-6.		51
	111-7.	LLNL conceptual design for JTACMS/CSWS warhead	52
	III-8.	Los Alamos conceptual design for AICBM warhead	52
	IV-1.	Assessment matrix	61
	V-1.	SLS of Army systems (peacetime)	6 9
	V-2.	SLS of Army systems (wartime)	70
	٧-3.	SLS of Navy systems	73
	V-4.	SLS of Air Force systems	75







6





GLOSSARY

ABM

antiballistic missile

ACM

advanced cruise missile (a conventional missile to be used by

the Navy to attack surface ships from a submerged submarine)

AD/ADA

air defense/air defense artillery

ADM

atomic demolition munition

AEC

Atomic Energy Commission

AF&F

arming, fuzing, and firing

AFAP

artillery-fired atomic projectile

AICBM

advanced intercontinental ballistic missile

ALCM

air-launched cruise missile

ALWT

advanced lightweight torpedo

AMSAA

Army Materiel Systems Analysis Activity

AR

Army regulation

ARRADCOM

Army Armament Research and Development Command

A-Site

nuclear weapons storage site that contains weapons assigned to

forward-based ground units

ASM

air-to-surface missile

ASP

ammunition supply point

ASTOR

antisubmarine torpedo ordnance rocket

ASW .

antisubmarine warfare

ATSD(AE)

Assistant to Secretary of Defense for Atomic Energy

DOE 6(3)

BN

battalion

BTRY

battery (element of an artillery battalion)

 c^2

command and control

CADMUS

controlled atomic demolition munition underground system

TINCL ASSIFIED

CASK convertible antiship killer (a convertible conventional/nuclear

missile to be used by the Navy to attack surface ships from a

submerged submarine)

CD/CDS command disablement/command disablement system

CEP circular error probable

CFRD confidential formerly restricted data

CNO Chief of Naval Operations

CNW convertible nuclear weapon (an INC weapon that has a nuclear

capability when the SNM is emplaced and a valid conventional or

chemical capability when the SNM is removed)

CNWDI Critical Nuclear Weapon Design Information

CNSI confidential national security information

COB collocated operating base

COMP component(s)

CONDOR Navy air-to-surface missile

CONT container

CONUS Continental United States

CRD confidential restricted data

CSWS Corps Support Weapon System (recently merged into the Joint

Tactical Missile system)

D³ delay, disrupt, and destroy

D-38 depleted uranium

DEFCON defense condition

DESTEX a form of conventional HE

DNA Defense Nuclear Agency

DoD Department of Defense

DOE Department of Energy

DT deuterium-tritium

ED emergency destruct

EOD explosive ordnance disposal

IINCLASSIFIED

LOADM

low-yield atomic demolition munition

MADM

medium atomic demolition munition

MGGB

modular guided glide bomb

MOB

main operating base

Modularity

general nuclear weapon design concepts that include insertable

nuclear components, convertible nuclear weapons, and

nuclear-only insertable nuclear components

DOD

Doe 5(3)

MRBM

medium range ballistic missile

MRR

minimum residual radiation

NATO

North Atlantic Treaty Organization

NCA

National Command Authority

NRC

Nuclear Regulatory Commission

NSC

National Security Council

NSI

national security information

NTS

Nevada Test Site

NUCL

nuclear

Nuclear-only

weapon

An INC weapon that has only a nuclear capability. It is not designed to have a valid conventional capability when the SNM

is removed.

NWDG

Nuclear Weapon Development Guidance

NWREP

nuclear weapon report

OCONUS

outside the continental United States

OPNAVINST

OPNAY instructions

OPS

operational effectiveness

OSD

Office of the Secretary of Defense

PACOM

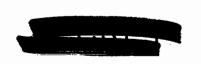
Pacific Command

PAL

permissive action link

PBXN

form of plastic-bonded explosive used by the Navy





PRP Personnel Reliability Program

PWW planar wing weapon

QRA quick reaction alert

RADM radioactivity atomic demolition munition

RD restricted data

RD&T research, development, and testing

RV reentry vehicle

RWC removable weapon component

SACEUR Supreme Allied Commander, Europe

SADM special atomic demolition munition

SAFF safing, arming, fuzing, and firing

SAM surface-to-air missile

SLCM sea-launched cruise missile

SLS stockpile-to-launch sequence

SNC separable nuclear component

SNM special nuclear material

SNW standard nuclear weapon

SOM standoff missile

SOP standard operating procedures

SRD secret restricted data

S-Site nuclear weapons storage site that provides storage for

specifically assigned unit weapons and initial resupply weapons

SSM surface-to-surface missile

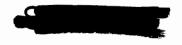
STF Special Task Force

safety, security, and survivability

STS stockpile-to-target sequence

SWOP special weapons ordnance publications

TASM tactical air-to-surface munition



EXECUTIVE SUMMARY

A. Overview

A nuclear weapons stockpile that is totally survivable, secure, safe, and operationally effective with a light logistic burden, all obtainable at a cheap price, represents the ideal world for the military services. This, of course, is an impossibility. As the pendulum of requirements swings in the direction of greater safety and security, survivability necessarily suffers, the nature of the problem being a choice between Scylla and Charybdis.

DOD

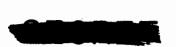
We undertook this study to determine if modular weapon technology offers not a panacea, but a means of improving the overall utility of certain types of nuclear weapon systems. It was intended to produce an essential first-reference document useful in determining the feasibility and utility of modular nuclear weapons, including insertable nuclear components (INCs).

For certain tactical applications, safety is enhanced, importantly, this enhancement should allow evolutionary modifications to existing stockpile-to-launch sequences (SLSs) and to administrative regulations that can substantially improve nuclear weapon survivability in the theater flexibility and allow for greater and operational effectiveness in special theaters.

B. Summary

We reviewed the studies that have addressed modularity, identified potential requirements for modular weapons, examined the technology needed to support modular weapons development, identified potential applications of modular technology, and evaluated the overall utility of developing and deploying these candidate modular weapon systems.







Although modular requirements have not been formally specified by the services, they have expressed varying degrees of interest in identifying the costs and benefits associated with incorporating modularity in the development of new tactical and strategic nuclear weapons.

DOD

Ironically some of the earliest nuclear weapons in the stockpile incorporated INCs, then called in-flight capsules.

DOE

The development of the sealed-pit weapons led to the demise of these early modular weapons around 1960. Technological advances plus increasing concerns for the survivability and security of the nuclear weapon stockpile led to a resurgence of interest in modular weapons during the 1970s

that has continued to the present.

Potential system applications for modular technology were evaluated in a matrix that compared families of weapon categories with 34 specific weapon characteristics. The strongest contenders for system/warhead technology are tactical systems, the most favorable being a land-launched missile/cruise missile, either convertible or nuclear-only; sea-launched tactical missile/cruise missile, again either convertible or nuclear-only; and an air-launched tactical bomb or air-to-surface missile (ASM) with a nuclear-only capability. Other tactical candidates scored very well but were not selected for the utility analysis: artillery fired atomic projectile (AFAP), torpedo, ADM, and air-to-air missile. Within the strategic categories, the mobile ICBM [surface-to-surface reentry vehicle (RV)] appeared to be a reasonable candidate for modularity, but it was viewed as another good follow-on candidate in view of the political and operational associated with mobile strategic systems in the continental U.S. (CONUS) at this time.





The utility analysis compared the advantages and disadvantages of modularity with three baseline systems in accomplishing tactical missions for each of the military services. All three candidates are high-value munitions and represent small buys.

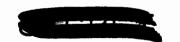
- The Army mission analyzed is two-fold:
- and provide conventional and possibly nuclear air-defense (AD) coverage at medium and high altitudes. The baseline systems are Lance, Hawk, and Nike-Hercules. The generic modular candidate is a convertible surface-to-surface missile/surface-to-air missile (SSM/SAM) system.
- The Navy's mission is to defeat enemy ships, submarines, and shore installations using the as the baseline conventional system, and a convertible modular system as the modular candidate.
- The Air Force's mission parallels the Army's first mission of the family of B57 and B61 gravity bombs make up the baseline. A dedicated force of nuclear-only TASMs is the candidate modular system.

DOD

A secure container with permissive action link (PAL) and command disable (CD) features protects the INC before insertion. The warhead body (WHB) contains the electrical interconnects to the missile guidance system and holds the IHE (or DESTEX for the Navy candidate) necessary to implode the pit. It does not contain RD information. The convertible applications also contain the unitary conventional high explosive (HE) or submunition explosives (or chemicals) in its remaining volume.

The major advantages and disadvantages of modularity as shown by the utility analysis are summarized in the section below. One important caveat t d t d athenrevs f service regulations in Chapter VI

tΤ



DOD

DOD

The advantages and disadvantages

are listed below; the service candidate affected is in parentheses.

<u>Pro</u>: (1)

(2)

(3)

(-)

(4)

(5)

<u>Con</u>: (1)

2. Security. Security is a condition that results from the establishment of measures to protect designated information, personnel, systems, components,

UNÇLASSIFIED

g 1, s-a



and equipment against hostile persons, acts, or influences. Several technical and operational advantages accrue to modular warheads.

 $\mathsf{D}^{\mathcal{O}^{\frac{1}{2}}}$

Pro: (1) Command and control requirements are now on components that are individually unable to produce a nuclear yield. (All three candidates)

(2)

DOD (3)

(4)

<u>Con</u>: (1)

DOF (3)

- (2) Peacetime dispersal to using units (Army) or deployment during crisis/hostilities to collocated air bases or strips (Air Force) for increased survivability means:
 - Exposure to more personnel.
 - Storage at less secure areas than the baseline unless storage wells or shelters are provided.
- 3. Safety. Safety enhancements are inherent within the INC technologies, regardless of whether or not a favorable administrative and regulatory environment evolves. Two types of safety are analyzed in this report: nuclear detonation safety where an inadvertent detonation gives a nuclear yield in excess of 4 lb HE equivalent, and plutonium-scatter safety where detonation of the HE results in dispersion of plutonium.

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs--the U.S. has a perfect record. However, modular warheads are safer before insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero. Though IHE has greatly reduced the probability of future plutonium





dispersal accidents with standard nuclear warheads, an accident involving the movement of a WHB (less INC) cannot disperse plutonium (it has none); an accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs.

- Pro: (1) Separation of explosives from nuclear material inherently increases nuclear detonation safety. (All three candidates)
 - a. Before insertion, modular warheads are safer than the baseline nuclear warheads.
 - b. After insertion, modular warheads are as safe as baseline nuclear warheads.
 - (2) Accidents involve lower probabilities of plutonium dispersal. (All three candidates)
 - (3) Intrinsic radiation concerns can be lessened by storing INCs in shielded containers. (Navy)
 - a. The INC is stored and transported in strong secure containers with only a small amount of IHE.
 - b. The WHB body is devoid of plutonium.
- Con: (1) Intrinsic radiation concerns are increased because of greater amounts of SNM in INCs if shielding is not adequate. (Navv)
- 4. Operational Effectiveness. Operational effectiveness as used in the analysis includes mobility, targeting flexibility, enduring capability, storage flexibility, nuclear yield, conventional warhead effects, reliability, range, and foreign political acceptability. The three candidates generally offer improvements over the baseline systems in this area.
 - Pro: (1) Strategic and tactical mobility for European and special theaters are increased because of the small size and weight of INCs and lack of nuclear materials in the WHB. (All three candidates)
 - (2) Convertible weapons can provide tremendous targeting flexibility. (Army, Navy)
 - (3) Enduring capability is available through the rapid logistic resupply of INCs. We think that early dispersal of the missiles and the non-RD WHBs to their field locations will substantially increase their survivability. (All three services)
 - (4) Convertible weapons allow full nuclear or conventional capabilities where storage areas are limited. (Navy)

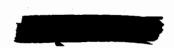




- Con: (1) Hard fixed-target requirements may necessitate a large and heavy two-stage INC. (Army, Air Force)
 - (2) Convertible weapons may incur reduced conventional effectiveness because of WHB volume devoted to the nuclear application. (Army, Navy)
- Do= b(3)
- with high production standards, affordable because of the small weapon system buys, and fully acceptable especially in insertion operations within a clean environment. (All three candidates)
- (4) Range for the nuclear mode of convertible weapons may be less. (Army)
- Unknown:
- (1) Foreign political acceptability of storing, docking, or overflying INCs and/or WHBs (without INCs) is unclear in areas currently restricted to nuclear weapons. (All three candidates)
- 5. Logistics. We examined the following subareas: transportation and handling, maintenance and support, storage requirements, special theater movements, training, limited-life component exchange (LLCE), administrative and security regulations, component classification, security personnel, and personnel reliability and inspections. Throughout we used the SLSs that were defined under a favorable environment where the missiles and WHBs do not require RD protection.

 $\frac{\text{Pro}}{\text{D}} : 0 \text{D}$ (1)

- b(3)
- (2) Size of storage areas requiring special nuclear protection is decreased. (All three candidates)
- (3) Training in unit areas and in the field can improve because of the greater availability of INC mock-up trainers and non-RD WHBs. (All three candidates)
- (4) Transportation of INCs into special theaters can be more rapid and secure than that of full-up nuclear munitions. (All three candidates)
- (5) Limited-life component exchange is easier. (All three candidates)
- (6) Maintenance and support workload and handling equipment are reduced for the INC. (All three candidates)





Con: (1) Administrative and security regulations must be adapted to engender viability of modular weapons in all utility areas (except safety, which is inherently increased). (All three candidates)

- (2) The WHB must not carry a classification higher than its delivery missile. (All three candidates).
- (3) Numbers of security personnel will generally be unchanged unless current storage sites become INC-only sites. Security personnel requirements and storage sites will increase if unit storage is allowed. (Army, Air Force)
- Unchanged: (1) Requirements for personnel reliability programs and inspections will probably remain the same. (All three candidates)
 - (2) Limited-life component exchange intervals and stockpile life will remain the same. (All three candidates)
- <u>6. Costs.</u> Life cycle costs including development, production, and operation and support categories were examined in a relative context. Though absolute cost numbers were not estimated, the merit assessment establishes the broad cost trends.

DOD

The Army and Air Force modular candidates are estimated to cost more, primarily because of increases in production, security, and storage costs. However, transportation costs are singled out as a category where substantial cost savings should be realized.

Pro: (1) Costs of a convertible warhead force are less than the costs of a dedicated nuclear plus dedicated conventional force. (Navy)

Con: (1)

DO = 6(3)

(2)

DOD

- (3) Production of safe, secure containers and construction of associated storage facilities may be expensive, particularly for the Army system. (All three candidates)
- Unknown: (1) Missile system operation and support costs account for about



fifty percent of weapon total life cycle costs. (If delivery unit life-cycle costs are considered, then the costs of INCs become practically negligible in terms of total life-cycle costs.) Costs may rise in certain areas, and fall in others. The overall effect is highly dependent upon INC storage schemes and security regulations, especially for the Army system. (All three candidates)

D. Recommendations

DOD

(1)

- (2) Recommend that the Laboratory continue to develop concepts for engineering designs to support modular systems in support of identified or perceived service requirements.
- (3) Finally, based upon specific service stated requirements, recommend that the Laboratory be prepared to develop modular warheads for production and deployment.





MODULAR WEAPON SYSTEMS AND INSERTABLE NUCLEAR COMPONENTS

A Compendium of Requirements, Technology, Applications, and Utility (U)

by

Joseph S. Howard II, Edward J. Palanek, John L. Richter, Richard R. Sandoval, Frank L. Smith, Richard H. Stolpe, CDR Larkin E. Garcia, LTC L. Warren

ABSTRACT (U)

This document is to serve as an essential first reference in determining the applicability and utility of modular nuclear weapons, including insertable nuclear components. Potential requirements for modular weapons were identified, past studies were reviewed, and warhead technologies needed to support weapons development were examined. The most promising of the potential applications of modular technology were evaluated in a utility analysis that covered survivability, safety, security, operational effectiveness, logistics, and costs. These analyses indicated potential utility of certain tactical modular applications. Recommendations are made that support continued Los Alamos development work.





CHAPTER I

INTRODUCTION

A. Purpose

The purpose of this study is to identify potential requirements for modular nuclear weapons, to review the technology needed to support modular weapons development, and to determine the feasibility, advantages, and disadvantages of developing and deploying one or more generic modular weapons in support of identified service missions.

B. Scope

The scope of this study includes:

- Defining modularity and various system configurations that constitute modularity and other pertinent terms required for understanding the subject area and this study (Chapter I and Glossary).
- Reviewing previous and on-going studies that address modularity and identifying the potential sources of requirements for development and deployment of modular weapons (Chapter II).
- Reviewing modular technology to include the advantages and disadvantages of implementation of the technology (Chapter III).
- Identifying potential applications of modular technology in terms of generic systems and applicable missions (Chapter IV).
- Evaluating potential applications in terms of operational effectiveness: safety, security, and survivability (S³); design limitations; and cost effectiveness (Chapter V).
- Reviewing publications and regulations that affect the development and deployment of modular weapons (Chapter VI).

C. Objective

The objective of this study is to bring together in one comprehensive document the previous and current work that has been accomplished in the area of nuclear weapon modularity, to evaluate modular technology applications to the missions and requirements of the armed services, and to determine the political and regulatory restrictions that apply. It is intended that this document will serve as an essential first reference in determining whether





modular technology for future weapons should be pursued, identifying weapon types and missions that might use modular technology, and postulating the political and regulatory restrictions that must be overcome.

D. Definition of Terms

Many terms have been used to define the concepts associated with weapons that have alternative warheads or require procedures to ready a complete warhead. In this study, we attempt to establish a set of distinct terms that define the entire spectrum of modularity concepts used here. Other terms used in the study are listed in the glossary.

Modularity - A nuclear weapon design concept that includes insertable nuclear components (INCs), convertible nuclear weapons, and nuclear-only INC weapons.

INC Weapon - A nuclear weapon design concept whereby a nuclear capable warhead can be converted from a nuclear-inert to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads: convertible warheads and nuclear-only warheads.

<u>Convertible INC Weapon</u> - An INC weapon that has both a nuclear capability when the special nuclear material (SNM) is emplaced, and a valid conventional or chemical capability when the SNM is removed.

Nuclear-Only INC Weapon - An INC weapon that has only a nuclear capability. It is not designed to have a valid conventional capability when the SNM is removed.

From the definitions above we see that there are two subclasses of INC warheads: (1) convertible warheads and (2) nuclear-only warheads. A convertible warhead is basically a conventional high-explosive (HE) warhead modified so a nuclear assembly, generally called an INC, can be inserted to give the weapon an optional nuclear yield. Convertible warheads may thus have either a nuclear yield or a useful conventional HE yield. With this option, the field commander can choose the yield (either nuclear or conventional) best suited to the delivery system, the battlefield conditions, and the target. Convertible INC designs may make many training and operational requirements



cheaper and simpler because the user need concern himself with just one basic weapon system instead of two. The nuclear-only INC design is used only with a nuclear yield. With either type, the nuclear assembly (the INC) is stored away from the basic weapon most of the time. The INC is inserted only after National Command Authority (NCA) release and, ideally, only after a target is at hand. During almost all the stockpile-to-target sequence (STS), the user does not have a nuclear weapon and thus has no nuclear safety problem, thereby avoiding many problems associated with maintaining, handling, transporting, and guarding nuclear weapons.





B. Overview of Specific Studies

DOD

that time, circa 1970, the nuclear-only INC did not meet with general political acceptance, but it did provide a springboard for the convertible INC. As then envisioned, a conventional warhead, preferably a precision-guided munition, could be simply and cheaply modified to give it a low-yield nuclear option.

2. Convertible Antiship Killer (CASK).3

DOD

CASK warhead was proposed to greatly increase large ship kill probability when operated in the nuclear mode.

DOD





- (7) Personnel would not be exposed to radiation hazards as they are with present nuclear weapons aboard submarines.
- (8) Perturbations to the DoD-developed warhead would be minimum, and the consequent reduction in kill radius for the conventional mode, depending on the design selected, would be no more than about 5%.
- (9) The entire allowance of INCs could be safely secured in a properly designated vault or safe.

DON	The conventionaltorpedo was in production when the study was
- -	conducted. This was a major disadvantage in considering a nuclear option.
	Incorporation of an INC option would probably have necessitated a redesign of
	the arming, fuzing, and firing (AF&F) circuitry, relocation of interior
	warhead components, and rework of the production facilities. This situation
	may have been the reason the Navy did not proceed with a convertible $oldsymbol{\mathbb{D}}$ $oldsymbol{\mathbb{D}}$
OD	torpedo. However, with the torpedo being completely upgraded, the Navy
	may again examine convertibility. Hughes Aircraft is retrofitting the total
	Navy inventory of over 2000 Mk 48s.

Field Command, Defense Nuclear Agency (FCDNA) Insertable Nuclear Report.5 (INC) This is the earliest source document that Component various of the then addresses aspects advanced nuclear-weapon design technology associated with the INC concept, both convertible and nuclear only. By this time the AEC had tested several INC design concepts at NTS and ACM, CASK. DOD had completed several conceptual (Phase 1) studies, CADMUS, and antiship missile).

CADMUS, and ______ antiship missile).

This report discusses the effects of the convertible and nuclear-only INC concept on: (1) command and control, (2) custody and logistics, (3) operational readiness, (4) safety, (5) security, (6) administrative aspects of the four safety standards (DoD Directive 5030.15 of 10 June 1960),

(7) relative costs, and (8) political ramifications.

5. Phase 2 Feasibility Study for Atomic Demolition Munitions (ADMs).6





DOEbl

DOD

This led the DOE design laboratories to respond with a variety of design proposals that appeared feasible. The problems associated with integrating a nuclear option (convertible INC concept) into the warhead and circuitry of the Harpoon were addressed in subsequent studies.

Conclusions resulting from Phase 2 and Phase 2A studies included: 9,10

• A nuclear-only replacement warhead compatible with the Harpoon weapon system is technically feasible and could be developed with little technical risk while satisfying modern nuclear weapons safety standards.

Therefore, the performance characteristics, sarety, and reliability of such a concept have not been fully evaluated.

 Various containers (shipping, storage, destruct) for the INCs have been identified.

The Phase 2A study 10 covered cost, commonality, and additional technical issues from the Phase 2 and resulted in a study recommendation for a convertible nuclear warhead with design considerations for future adaptation to the antiship missile. The cost analysis concluded that: (1) excluding cost of special nuclear material, there is no significant cost difference between convertible and nuclear-only designs, and (2) a convertible warhead is more cost effective than a nuclear-only system in terms of operational flexibility. In summary, the convertible nuclear the commonality analysis concluded that a high commonality level could be



UNCLASSIFIED

DOD

DOD



achievable for Navy low-yield warhead applications and would reduce Navy and DOE costs because of common weapon development and production. The two main technical issues were resolved by actual tests; that is, the convertible warhead survived in the conventional mode, and the Navy conventional HE (DESTEX) could be used in the convertible nuclear warhead. Phase 3 development engineering could be initiated immediately for either a nuclear-only or a convertible warhead for the weapon system. The technical risks associated with developing either a nuclear-only or convertible warhead were judged low.

8. Convertible Concepts for the Mk 84. 11 The Air Force, with the participation of the DOE design laboratories conducted a study on the utility of giving the Mk 84 bomb a convertible INC option, especially when using the guided glide bomb (GGB) derivatives of the Mk 84: GBU-8, GBU-10, GBU-15 (V). The study included six proposals ranging from self-contained nuclear weapon add-ons to small capsule-type nuclear components. The designs were selected to illustrate the possibilities of the convertible INC concept and to show that application is highly system-dependent. Though several distinct benefits were identified, a formal requirement did not materialize.

"Convertible Concepts for the Mk 84" was the forerunner of a large and comprehensive study effort by the Directorate of Aerospace Studies entitled "A Utility Analysis of Convertible Nuclear Weapons." The two study efforts overlapped to some degree but the Mk 84 study is narrower in scope. Much of the information furnished by the then ERDA laboratories for this effort was used in "A Utility Analysis of Convertible Nuclear Weapons."

9. A Utility Analysis of Convertible Nuclear Weapons. 12,13 This report investigated the operational feasibility of convertible nuclear weapons (CNWs) and analyzed their utility in comparison with standard nuclear weapons (SNWs). The concept was found feasible for lower-yield ranges. The CNWs also used new protective devices and storage facilities more effectively than SNWs because of their small size and the separability of the nuclear explosive package from the HE of the conventional weapon.

						بلعر			7		3.4	
DOD	10.	Nuclear	Convert	bility	for	the			An	Analysi	s. 14-	The
	main con	clusions	of this	FCDNA	anal	ysis p	rovide	one o	f the	best	conder	nsed
100	overviews	of co	nvertible	e nucle	ear 🏅		advan	tages,	incl	uding	a mat	trix
	checklist	t of adv	antages	and di	sadva	ntages	. The	genera	al con	clusio	n s ta f	tes:
DOD	"The tot	al cost	for the	convert	ible	nuclea	r	CON	pared	to the	basel	line
Don	пле тот	ai cost	tor the	convert	101 e	nuclea	r	COT	npared	to the	Dasel	חרו



	nuclear is about equivalent. The convertible nuclear	benefit	
	clearly outweigh those of baseline nuclear		
	11. Phase 1 Study for the GBU-15 Planar Wing Weapon (PW	<u>₩)</u> . ¹⁵ This	
	study examined the concept of equipping the GBU-15 Planar Wing W		
	with a nuclear capability. The nuclear GBU-15 PWW would		
	commonality with the conventional PWW.	meser so en timese	
:			
1			
-	One	an see the	
1	Company of the second of the s		
	possibility of a wide range of employment configurations for the GBU		
	12. The Effectiveness of a Convertible Warhead. The effecti		
	convertible warhead, when used in the conventional HE mode, compare	d with th at	
	of the original unmodified conventional warhead was addressed by Los Alamos in		
	an outgoing telecommunication message to ATSD(AE) on August 1, 1977.		
	The blast effectiveness of a conventional HE warhead is proportional to		
	the cube root of the mass of HE. When such a weapon is modified to make it		
	convertible, its yield, and consequently its effectiveness, may or may not be		
		שוות א ווטנ שכ	
	reduced from that of the original unmodified warhead, depend		
Ŧ	convertible design used.		
Ŧ			
f			
7			
7			
4			
4			
4			
+	convertible design used.	ing on the	
+	It is possible to design INC convertible warheads that are ful	ing on the	
	convertible design used.	ing on the	
	It is possible to design INC convertible warheads that are ful	ing on the	
***************************************	It is possible to design INC convertible warheads that are ful	ing on the	
***************************************	It is possible to design INC convertible warheads that are ful	ing on the	
	It is possible to design INC convertible warheads that are ful	ing on the	
	It is possible to design INC convertible warheads that are ful	ly equal in	

34

Part 2 concludes that the INC weapon concept offers an attractive alternative for obtaining greater capability within a constrained budget. Additional savings are possible if the same INC can be shared among various convertible weapon systems (INC commonality).

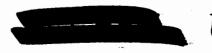
14. Recent Work on Insertable Nuclear Component (INC) Warhead Designs. 18 This report summarizes the Los Alamos design and development work on INCs to the year 1977.

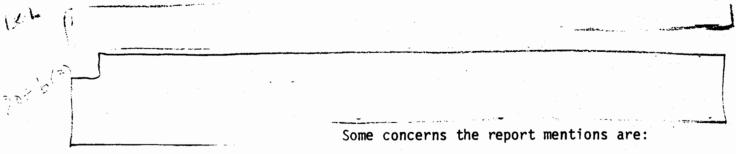
P(3)

DOD

106 106

DOE





00 & p(3)

(2) Existing ERDA classification rules affecting the nonnuclear portion of the warhead might need revision to accommodate the warhead when the INC is not in place.

(b)(3) DOD

(3)

- (4) Production plans for the weapon might need altering in order to accommodate INC needs.
- (5) Cost studies of convertible warheads vs conventional HE/regular warheads and the cost of the SNM must be determined because cost is an important consideration in the overall evaluation of the weapon.
- Separable Nuclear Components. This study provides an initial but detailed qualitative assessment of a nuclear weapon design concept termed the "separable nuclear component (SNC) concept" and focuses on military rather than technical factors. Advantages and disadvantages of SNC weapons in comparison with standard sealed-pit nuclear weapons are analyzed, and their dependence on policy, posture, and weapon design factors is examined. The value of the SNC concept under four postulated theater nuclear force postures is analyzed. Potential applications of the SNC concept to delivery systems are considered and ranked as to potential merit. Political and other implications of introducing SNC weapons are discussed.
- a. Conclusions. The study recommends that SNC weapon programs at the nuclear weapon laboratories should be reviewed to ensure that they are properly oriented and that factors such as military advantages, design feasibility, and costs are evaluated and constantly updated to allow for the latest developments in the field. The report suggests that DOE should continue conceptual design efforts on the SNC while emphasizing warheads for







theater-level ORA mobile missile systems and should try to get an SNC weapon where the RWC would not have a restrictive security classification. Further, the DoD should work closely with the DOE in evaluating the political-military utility of SNC weapons and in evaluating delivery systems which now appear to have high merit--specifically GLCM, MRBM, Pershing II and ADM.

Tactical Air-to-Surface Munition (TASM). The Air Force, with the assistance of the DOE laboratories, completed a pre-Phase 1 study of a nuclear during 1976-1977.^{20,21} A Phase 1 SOM air-to-surface period of 1979-1980.²² during the The results substantial payoff when attacking mobile and fixed targets with an SOM as compared with nuclear gravity bombs. Though the study did not address INC systems, prelaunch survivability was a major concern with sealed-pit weaponry because of their constrained storage at main operating bases (MOBs). An INC weapon system may allow a large gain in survivability by deployment to numerous collocated operating bases (COBs) and alternate airstrips during crises.

	17. Compendium of Convertible Technology. 23 This report is designed to
	provide an overview of the convertible concept by extracting from previous
	Navy studies the perceived advantages and disadvantages of the convertible
Dod	concept. The Phase 1, 2, and 2A studies are examined because they are
	the only studies that attempted to quantify the advantages and disadvantages;
	these studies also recommended that a convertible system proceed to Phase 3,
DOD	development engineering. The conclusions of the effort are reiterated
	and those conclusions that are system-independent are highlighted.

Table II-I, extracted from the report, provides a trade-off evaluation of convertible versus standard nuclear weapons.

.

On the other hand, (1) convertible weapons are less costly taken overall than standard nuclear weapons, (2) designs can be modified so that

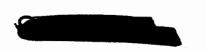




TABLE II-I

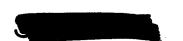
TRADE-OFF EVALUATIONS

Competing Characteristics Choice Rationale

D∂€ 6(3)



and reliability of the weapon after INC insertion in the field that need resolution. Dog Advanced Intercontinental Ballistic Missile (AICBM). concept currently being investigated concerns small intercontinental ballistic missiles (ICBMs) deployed under different basing concepts. concept is a road-mobile system, but air-mobile, air-transportable, and silo basing concepts are under consideration. To increase survivability, the system could be deployed as a mobile system over a road network. Because of the proximity of the warhead to the missile propellant, significant safety concerns are raised when using standard sealed-pit warheads. Security concerns are of an equally severe magnitude because a full-up nuclear warhead is away from a fixed site. Accidental nuclear detonation would be an impossibility unless the system was properly mated. C. Summary of Service Requirements In October 1977, the National Security Council (NSC), in reviewing the underground nuclear test program proposed by DOE/DoD, held approval of two tests in abeyance pending the DoD submission and interagency review of the military utility and arms control implications of INCs. DOD Several aspects of the NSC request proved so contentious within DoD that no response was provided. Certain offices in the Office of the Secretary of Defense (OSD) objected DOD to the Navy rationale for a nuclear i At that time. there was substantial opposition in OSD to any sea-based tactical nuclear weapons. Accordingly, Navy suspended consideration the of LOL capability and DOE terminated active programs related to INCs pending resolution of the impasse between the DoD and the NSC over the



military utility study. 25 The DOE recently rescinded its freeze on testing of INCs and is allowing laboratory development to proceed. 26

There is growing interest in the potential advantages of INCs within DoD and DOE, evidenced by the Army request for inclusion of INC warheads in the CSWS/JTACMS program. Another indication of interest in INC is the Chief of Naval Operation's (CNO's) memorandum stating the Navy policy to support further research and development of INC technology, to determine its full capabilities, and to consider incorporation of INC technology in development of new weapon systems. 27

 D_{0D}

D01

DOB 6(3)

DO6 6(3)

Do € b(3)

10E 6(3)

D 0€ b(3

43

DOE

During the same time frame, gun-assembled (GA) weapons were deployed. Figure III-2 shows a cutaway of the Mk 33 8-in. projectile, which is still deployed in large stockpile numbers.

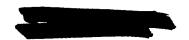
DUD

DOE 6(3)

C. Benefits of Early IFI and GA Weapons

The IFI weapon bodies were flown on alert and there were accidents that involved scatter of SNM. Without delving into details, the IFI designs prevented large-scale health hazards or loss of life because of the separation of the INC from the remainder of the bomb body. The results from an air crash involving an IFI weapon were: loss of life and aircraft, intact survival of

90E 6(3) TOL



the secondary (if there was one), and scattered uranium at barely detectable levels if an HE explosion or fire occurred. The nature of ionizing radiation allows one to conclude that if it is not detectable with modern instruments, then it is not hazardous to life. Uranium has very feeble radioactivity: 4.5 x 10^9 year half-life for 238 U and 0.71 x 10^9 year half-life for 235 U. In order to put into perspective the hazard of uranium scatter, we note that commercial airliners use depleted uranium as a counterweight material for control surfaces; a Boeing 747 uses about 500 lb of 238 U. Unfortunately, airliners crash and burn and sometimes scatter 238 U. Whether society is aware of it or not, it has accepted the (infinitesimal) peril of uranium scatter.

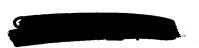
P(3)

DOE 6(3)

D. Disadvantages of Early IFI and GA Weapons

The IFI weapons were fielded with increasingly complex mechanisms for effecting in-flight insertion. During alert flights, the real bomb bodies were mated with the cores, and the Air Force literally wore them out. Many of the IFI bombs required a weapons officer in the bomb bay. As modern aircraft were developed, the presence of a man in the bomb bay became impossible.

The GA weapons were supplied with trainer weapon bodies as well as mock-up oralloy. The still-in-service W33 is assembled from the ground up in the field. A special truck with an officer and two specialists are required to





assemble an 8-in. weapon. Couple this with the need for a cordon of guards and one has an awkward logistical problem. A highly proficient team can assemble an 8-in. weapon in 45 min; then they handcarry the assembled weapon to the nearby 8-in. howitzer.

E. Sealed-Pit Technology

DOE b(3)

DOE 6(3)

The convenience of the all-up round without

having to assemble the hardware is very attractive to the military.

The first sealed-pit weapons entered service in 1958, causing production of IFI weapons to cease. The safety crisis came in early 1966 with the accident at Palomares, Spain. A B-52 bomber on airborne alert collided with a KC-135 during a routine refueling operation. Four B28 weapons either fell out or were jettisoned from the falling bomber. One of the bombs fell into the Mediterranean Sea and was recovered relatively intact after about two months. Another soft-landed on the ground because the parachute deployed. The HE of one of the other B28s that hit the ground deflagrated, and the HE of the last one detonated. There was no nuclear excursion from either of the last two, but the plutonium was scattered around the area. Plutonium is pyrophoric, and if it is heated in the presence of air, it will burn and form an aerosol of plutonium oxide. Plutonium ingested through breathing or cuts is a very serious health hazard.

DOE 6(3)

Several acres of topsoil were scooped into barrels

and buried at the Savannah River site in South Carolina.





About two years later in early 1968, another airborne-alert B-52 caught fire. The pilot dropped the crew by parachute and then rode the airplane down to a burning crash on an ice floe in North Star Bay, Greenland. The contaminated iceberg was cleaned up at greater cost than the contamination at Palomares. As a result of these accidents, the U.S. stopped flying alert bombers. Work to prevent future Palomares- and Thule-type accidents continues. One important result is the introduction of IHEs.

D0 €

However, IHE is extremely insensitive and provides much greater safety. A modern, high-performance, nuclear weapon primary with IHE weighs considerably more than similar technology with the HMX-based explosive. Although many new tactical weapons (except the AFAPs) are being designed with IHE, there is no hint that alert bombers will take to the air with IHE bombs on a routine basis.

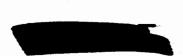
The use of IHE and Cat F PAL (see Cat F PAL in Section F.1.a below) in modern weapons is increasing. These features undeniably increase safety but can result in decreased weapon effectiveness. That is, for a given weight, volume, or SNM usage, the yield may be less. The INC, or modular, weapon can fulfill safety requirements for reduced plutonium scatter without IHE and can protect the separate, vital weapon components without a Cat F PAL built into the weapon. For these reasons, the INC may be a more attractive alternative than the ever more complicated all-up weapon.

F. Current Concepts for Modular Weapons

1. Modern Weapon Systems Architecture. Essentially all nuclear weapons can be considered to be "insertable" in a sense. The B61 is a full-fuzing-option tactical bomb.

005 b(3)

Another example of a weapon that could be considered insertable is the Pershing missile. It has a removable warhead section that is stored separately from the missile. The warhead will not function unless it is mated to the missile and properly launched. Or as a final insertable example, an



AFAP will not operate unless it is properly fired from a howitzer. But while these systems are modular in this sense, they are not truly INCs according to the definition in Chapter I.

a. Cat F PAL. A new feature included in many modern nuclear weapons is the Cat F PAL. This is a feature built into the weapon to protect it from unauthorized use.

b. Emergency Destructs (EDs). The DoD also has developed Standard
Operating Procedures (SOPs) for emergency destructs.

2. Recent Separable Component Concepts.
a. Figure III-3 shows the convertible concept offered by Los Alamos for the With only a trivial reduction in HE

Fig. III-3. Los Alamos Harpoon Proposal 3A warhead.



DOG (

COL

DOE 31

UNCLASSIF role. DOE 6(3) weight, the weapon body can be used in the conventional! Dor 6(3) DOE 6(3) The test device did not include INC attributes because the testing of INC weapons had been banned by Presidential Order DOE bCi DOE 6(3) DOE 6(3) 00E 6(3) 49 UNCLASSIF

							-	=-1
	c. Appl	ejack.]	•	Tox.				
-								
)0E (3)								:
ا في ا								
+ .								
	1							000
₹ 1	•			غند			•	
DOE							·	
0€ 1 b(3)								
ne								
0E 6C3)	* Palano		•					
						Carrier Section 1		
	1			••				
						•		
				•				
DE	6(3)							
De	ן מנ							
$\mathcal{L}^{\mathcal{L}}$								
	1							
	-	Fig. III-5.			2		<u>/</u>	
50						DOEP	<i>)</i> 1	

D0 603

Fig. III-6.

DOE 6(3)

DOD

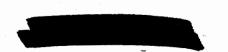
Two problems associated with the concept are reliability and i_{0} efficient use of SNM.

e. Two-Component Insertable Nuclear Component (INC). Figure III-7 shows the LLNL concept (Waxwing) for the CSWS/JTACMS. The concept involves a nondescript cavity in the warhead. First, the INC hardware package is installed; then the remaining volume is filled with paste HE. The objective is that the nondescript cavity will be unclassified.

The road-mobile missile may eventually use HMX-based DOE propellant, so HMX in the warhead might become acceptable, especially with the separation of the INC.

G. INC/Convertible Warhead Observations

The IFI and GA weapons were of the era when the AEC developed weapons with less consideration for logistics or employment than is now possible, given their experience and knowledge. It is safe to say that the detailed concept



DOD

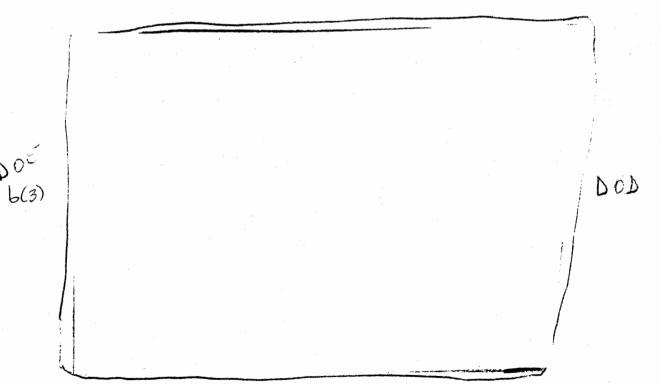


Fig. III-8. Los Alamos conceptual design for AICBM warhead.



	the 1970's INC							*****	-	
torpe	does, modular	g u i d e d	glide l	comb (MGGB)	with	<u>the</u>	Mk 84	4 2000–1	lЬ
general-purp	ose (GP) bo	omb as	the n	nuฏitio	on,				Selectiv	/e
					agrana					
	can be made c	oncernin	n each o	of thes	EPINCE	ttori	٠. 2			
observations	can be made c		-					anly	enacific	
observations Unwritte	n nuclear wea	pon empl	-					only	specifie	<u>•d</u>
observations Unwritte		pon empl	-					only	specifie	<u>•d</u>
observations Unwritte	n nuclear wea	pon empl	-					only	specifie	<u>ed</u>
observations Unwritte	n nuclear wea	pon empl	-			ers 1	that		specifie	

DUD

The tritonal was cast into the for product uniformity but with

"low-value" Mk 84 bombs with little concern for product uniformity but with great regard to cost. There were questions about whether a mill run Mk 84 bomb, modified for convertibility, would operate reliably.

The high-value (classified and expensive) weapons are protected much more carefully by the services than low-value weapons. The latter category includes rifles, cartons of Composition C, artillery ammunition, and GP bombs. Since high-value munitions are protected because of cost, classified components such as guidance, and the threat of misuse, it may be that adequate precautions are already in use to protect a convertible or INC.





CHAPTER IV

POTENTIAL APPLICATIONS OF MODULAR TECHNOLOGY

A. General

The objectives of modular technology are to increase the military utility of applicable weapon systems with minimum operational burden and cost to the user. These objectives are achieved through weapon design which is system dependent. Therefore, it was determined that the advantages and disadvantages of modular technology must be analyzed by comparing a set of weapon system/warhead characteristics with weapon categories that group "like" types of weapons into specific strategic and tactical categories.

It has been found in the past that evaluation of generic systems for adaptation of modular technology has not been successful because of the uinique character of each system. To minimize the impact of this problem, the weapon system/warhead characteristics and weapon categories where chosen so as to provide a reasonably definitive weapon "type" without actually selecting a system either deployed or in development.

B. Approach

A single matrix was developed for a generalized list of weapon categories and an assessment was made concerning the impact of modularity on the weapon system/warhead characteristics. The following assessment factors were used:

- Very positive impact
- Some positive impact
- No change
- Netgative impact
- Not applicable

For the assessment, certain assumptions were made and additional factors considered in determining the impact of modularity on systems within the weapon categories developed. The systems were evaluated on the basis of the STS of like-type systems currently deployed. From this evaluation, which is qualitative rather than quantitative, three of the most promising candidates were selected for a more detailed utility analysis.





<u>l. Weapon Categories</u>. The widely-used lists of strategic and tactical weapon systems were grouped into like types of weapons in specific strategic and tactical categories. This was done to develop a workable matrix and to more readily identify categories of systems that might benefit from modular technology. The weapon categories used in the assessment are as follows:

Strategic

Surface-to-Surface Reentry Vehicle

- Fixed
- Mobile

Air-to-Surface

- Bomb
- Cruise Missile

Air-to-Air-Missile

Strategic Antiballestic Missile

Tactical

Surface-to-Surface

- Projectile
- Reentry Vehicle
- Cruise Missile
- Short Range Missile

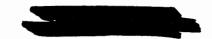
Air-to-Surface

- Bomb
- Cruise Missile

Antisubmarine Warfare

- Cruise Missile
- Torpedo

Surface-to-Air-Missile



Air-to-Air Missile

Atomic Demolition Munition

2. Weapon System/Warhead Characteristics. The advantages and disadvantages of modular warhead technology were analyzed for each weapon category by comparing their impact on 34 specific weapon system/warhead characteristics. These competing weapon system/warhead characteristics are intended to establish a broad set of measures encompassing a relatively complete range of attributes desirable for nuclear weapons. These weapon system/warhead characteristics, and their definitions, are as follows:

Command and Control $({\tt C}^2)$. Those features that limit warhead/warhead section use only to authorized personnel during circumstances specifically designated by proper authority. Features such as PAL and nonviolent disablement are specifically included.

Convertible Weapon (Dual Capability). A type of INC weapon that has both a nuclear capability when the SNM is emplaced and a valid conventional or chemical capability when the SNM is removed. (The fact that an HE plug, specific submunition, or chemical agent must be emplaced in the cavity intended for the INC, to attain a valid conventional/chemical capability in some designs, does not eliminate those designs from the convertible weapon category.) (Technical Publication, TP 4-1)

<u>Cost</u>. Actual or potential expenditure of dollars and SNM required to develop, produce, and support a weapon capability throughout its life.

<u>Design Impact</u>. The impact of nuclear design on the weapon system when considering the following design requirements.

- Primary only
- Primary with boost



- Classification of WHB
- LLC considerations (the impact of modular technology on LLCs and changeout periods)



Des

DOE (a)(3)

<u>Desired Yield Range</u>. The capability of modular technology to provide the required yield range.

!	The state of the s	The second second
Destruct (Violent).		100 E
	. (TP 4-1)	b(3
The state of the s	10	

<u>Disablement Nonviolent</u>. Nuclear weapons disablement which, through the destruction or disassociation of one or more key warhead or warhead section or atomic projectile components, temporarily destroys a weapon's ability to be used in its intended mode or as an ADM. (TP 4-1)

<u>Economy of Nuclear Material</u>. Judicious design of active materials and designated special weapons materials whose possession and use are licensed and controlled by the Nuclear Regulatory Commission (NRC).

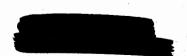
<u>Explosive Ordnance Disposal (EOD)</u>. Activities involved in render-safe procedures and the safe removal of explosive ordnance.

INC Weapon. A nuclear weapon design concept whereby a nuclear-capable warhead can be converted from a nuclear-inert warhead to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads—convertible and nuclear-only.

<u>Intrinsic Radiation</u>. Nuclear radiation intrinsic to a weapon and emitted through the weapon's outer surface.

<u>Maintenance</u>. The actions necessary to maintain material in the desired state of operational readiness throughout its life cycle. Maintenance functions include checkout, servicing, crew augmentation, replacement, modification, and depot maintenance. (U.S.A. TRADOC PAM 71-12)

<u>Mobility</u>. The capability of the system to be easily moved in an operational environment.





Operational Effectiveness (OPS Effect). The capability of a system to perform the missions for which it was designed.

Personnel and Training. The number of personnel required and skills necessary to operate, maintain, and support the material system in its operational environment throughout its life cycle. Training includes the identification of personnel skills, training devices and aids, instructions, training documentation, and manuals required to support a material system. (U.S.A. TRADOC PAM 71-12)

Range. The impact of modular technology on system range.

Regulations and Directives. Official DOE, DoD, and armed services publications that establish or implement policies or procedures governing all phases of the life cycle of a nuclear weapon.

Reliability. The probability (without reference to countermeasures) that a weapon will detonate when it has been delivered to its target. (TP 4-1)

<u>Risk (Technical)</u>. The degree of probability that a technical goal will be achievable in the system considered.

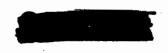
<u>Safety (Munitions)</u>. The prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. This should include nuclear, HE, and plutonium-scatter safety.

<u>Security</u>. A condition that results from the establishment of measures which protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. (JCS PUB 1)

Stockpile Life. The period of time a warhead is available for employment by DoD.

Stockpile-to-Target Sequence Environment. The aggregate of all external conditions and influences affecting the weapon throughout the STS, including transportation, maintenance, storage, and launch. Factors included are





temperature, humidity, and contaminants of the surrounding air; physical location and operating characteristics of the surrounding equipment and occupants; operational procedures such as acceleration, shock, vibration, heating effects, and radiation. (TP 4-1)

Support/Maintenance Facilities. Facilities to support the material system. Examples are: physical plant, real estate, portable buildings, concrete pads, revetments, roads, runways, housing, shops, depots, test sites, computers, training facilities, and storage areas.

<u>Survivability</u>. The capability of a system to withstand a manmade hostile environment without suffering abortive impairment of its ability to accomplish its designated mission. (TP 4-1)

<u>Testing</u>. The procedures and equipment required of DoD personnel (at any level) to certify the reliability of the system, or any of its components, in contrast with the more "conventional" nuclear system.

Transportation and Handling. The procedures, equipment, materials, and facilities needed for packing and crating; the use of reusable containers; supplies necessary to support packaging, preservation, storage handling, and/or transportation of prime equipment; support and test equipment needed; repair parts and supply support; personnel; technical data; publications; and facilities. (U.S.A. TRADOC PAM 71-12)

<u>Yulnerability</u>. The characteristics of a system that cause it to suffer a definite degradation as a result of having been subjected to a certain level of effects in an unnatural (manmade) hostile environment. (TP 4-1)

- 3. Assumptions and Additional Considerations. In development and assessment of the matrix of potential modular applications, certain assumptions and considerations were applied.
 - (1) Evaluations were made on the basis of providing something better with modular technology than currently exists in a standard nuclear warhead design.





(2) Certain warhead characteristics were weighed more heavily than others in this assessment. These were

design impact

operational effectiveness

safety

security

survivability

transportation and handling

- (3) It was assumed that modular design technology would use relatively higher amounts of SNM; therefore, economy of SNM would reflect a "negative" in most generic system considerations.
- (4) Generally, a reduction in reliability can be expected in most modular technology designs and was so reflected for all generic system categories.
- (5) Deployment of modular systems would necessitate a restructuring of current regulations and directives addressing nuclear weapon storage, transportation, and handling, and therefore reflect a negative impact.

C. Assessment

- 1. General. Evaluation of the matrix found in Fig. IV-1 indicates that the strongest contenders for modular technology are tactical systems. Those tactical systems that appear to be the most favorable modular candidates but still allow adaptation to other tactical uses include the following:
 - (1) Land-launched tactical missile/cruise missile (SSM/SAM), either convertible or nuclear-only
 - (2) Sea-launched tactical missile/cruise missile (SSM), again either convertible or nuclear-only
 - (3) Air-launched tactical bomb or air-to-surface missile with a nuclear-only capability

These three candidates can cover a wide variation of STS environments and system variations. Other systems identified for future consideration in modular technology applications include the strategic mobile missile system (AICBM), an air-to-air missile (for strategic or tactical use), and several tactical-only systems.

2. Specific Assessment Considerations. A number of observations can be made in reviewing the matrix and resulting evaluation.



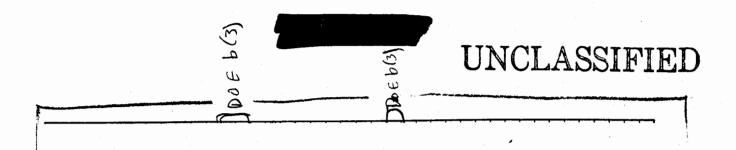


Fig. IV-1. Assessment matrix.

(1) Certain characteristics reflect strong support for modularity technology in all weapon categories. These include

destruct (violent)

disable (nonviolent)

explosive ordnance disposal (EOD)

These three categories encompass security measures designed to ensure against theft or unauthorized use of nuclear weapons. By separation of components, the modular concept provides inherent improvement in security during peacetime and in crisis against the threat of theft





or unintended use. Standard nuclear weapons are not generally amenable to such methods of use denial except through design and operational measures that are relatively cumbersome in comparison to component separation.

(2) Those tactical systems that appeared to be the most favorable candiates for application of modular technology reflecting strong support in the following additional warhead characteristic categories.

command and control

yield range

mobility

safety

security

small volume/lightweight

stockpile-to-target sequence environment

support/maintenance facilities

survivability

transportation and handling

vulnerability

design impact (primary and boost)

Do € 6(3) Do € (3)

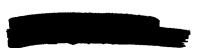
(4) Some tactical candidates scored very well but were not selected.

000

Projectile._

it was considered improbable that a new projectile would be considered for development in the near term.

<u>Torpedo</u>. A new nuclear torpedo has been under development consideration for several years but is still in question. There is a good possibility that modular technology would have application for



	orpedoe		systems,	ei ther	a new	torpe	do or	in	retro)f
Atomic	Demo1	ition	Munition.	The	develo	oment	of a	new	ADM	
			s time.							

<u>Air-to-Air Missile</u>. The requirement here could have Air Force and Navy applications but does not appear to have the urgency that the selected candidates reflect in meeting projected DoD needs. This would be a good follow-on candidate for modularity consideration.

(5) Within the strategic categories, the mobile ICBM [surface-to-surface reentry vehicle (RV)] appeared to be a reasonable candidate for modularity, but in view of the political and operational problems associated with mobile strategic systems in the CONUS at this time, it was viewed as another good follow-on candidate.



CHAPTER V

UTILITY ANALYSIS

A. Introduction

This chapter examines the utility of modular nuclear warheads within the context of three generic candidates, one system for each of the military What we have attempted to do is address the advantages and disadvantages offered by these kinds of warheads. We recognize that hardware is only one aspect of the military equation; the conclusions we reach here must be tempered by the existing political and military doctrinal environment and especially by the current administrative framework. Many including the element of political and military strategy. leadership. personnel training, application of the principles of war, and modus operandi of the STS, are major parameters that ultimately drive the real worth of these systems whether in peacetime deterrence or wartime application. the focus is within the European environment where the survivability of our nuclear forces has been and continues to be severely questioned. We see that potentially offer a substantial nuclear weapons increase survivability, particularly for the Army and Air Force candidates. But. turning away from our potentially most important war area to those areas of the world where wars may be more likely, a force of Army or Navy convertible systems offers tremendous flexibility to respond conventionally and to deter nuclear responses within special theaters. Several advantages, including the all-important increase in survivability, also accrue to the Air Force candidate modular system that is dedicated to the nuclear role.

Let no one doubt that obstacles must be overcome to field successfully these kinds of warheads. The technical challenges, however, are not high risk. Reliable and safe modular warheads can be built using present design and engineering capabilities. It is their impact upon the well-established administrative, security, and surety community that involves major ramifications. If modular systems are treated as "business as usual," then only safety advantages result from the separation of plutonium from the HE during most of a warhead's life. Instead, the logistic and regulatory community should modify the peace-time logistic system in order to realize a survivable nuclear system, even with the probability of an increase in costs. Increases in survivability should be



the primary reason for developing, producing, and deploying modular nuclear Though the benefits of having safer warheads are of great importance, we realize that modern standard warheads have an unblemished safety record regarding accidental nuclear detonation;

The real benefits in safety improvements lie in allowing changes in the transportation and storage of nuclear weapons that, in turn allow greater dispersion and enhanced survivability. Personnel training needs high emphasis, not only in the obvious mechanics of inserting the nuclear component into the WHB or in installing additional submunitions in a field environment, but also in the total tactics of moving from unit kasern to field locations, or in deploying to collocated Air Force bases, or in changing missile capabilities afloat, as the service case may be.

Beyond the scope of this analysis are several important areas that will have an impact on modular warhead deployments. We do not examine the arms control ramifications which are always of concern to military planners when trying to field new hardware. We also do not examine the strategic and tactical doctrine under which the Armed Forces operate. Both of these factors can affect the ultimate utility of modular weapon systems. In this utility analysis, we assume away the arms control problem and accept the major tenets of the present doctrinal framework (such as flexible response) in applying our logic. We do modify some of the underlying tenets to exploit the utility of modular weapons.

Other political and military considerations, more microscopic in nature, do require treatment. In this analysis, we treat these considerations under a generally favorable environment in order to determine the advantages and disadvantages of modular systems.

initially describe the generic weapon systems. then take characteristics used in Chapter IV to identify potential modular applications and examine them through a taxonomical structure consisting of sections on safety, security, survivability, operational effectiveness, logistics, and Relative utility numbers are generated for each section and then aggregated to try to quantify the advantages and disadvantages; the reader can accept or reject this tool yet still support the findings in the summary section which ends the chapter. The conclusions and recommendations that emerge from this utility analysis are given in Chapter VII.





B. Weapon Description and Stockpile-to-Launch Sequence (SLS) Differences

- 1. General. The approach of this section is to describe initially the candidate modular warheads, then to describe the three modular weapon candidates, and finally to compare their SLSs with the baseline systems. All three candidates are low-quantity buy, high-value munitions.
- 2. Candidate Modular Warheads. Two warhead candidates are chosen to satisfy potential tactical yield requirements. We vastly prefer the first candidate because of its smaller size, lower weight, and simple design.

The second component is the WHB. For the nuclear application, Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.										
The second component is the WHB. For the nuclear application, Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.	<u> </u>	<u>a. W</u>	arhead Candidate	s #1.		.~				
The second component is the WHB. For the nuclear application, Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.	.									
The second component is the WHB. For the nuclear application, Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.	}									
The second component is the WHB. For the nuclear application, Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.										
Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.	; }									
Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.									-	
Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.				and the second second in			The seco	nd compor	nent is	•
volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD.		the WHB.	For the nucle	·	-				The second se	
WHB body would not contain RD.		THE RESERVE THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN COLUMN TWO IS NAMED I		178	•					
· · · · · · · · · · · · · · · · · · ·		investigat needed to is warran	ions in the ar determine if a ted for convent	reas of co conventiona tional miss	sts, ran 1 HE fil sions an	ge, safe ler plug d if th	ety, and for the ca e convent	reliabili nvity in ional mu	ty are the WHB nitions	
		investigat needed to is warran normally	tions in the ar determine if a ted for convent in the WHB shou	reas of co conventiona tional miss ld be remov	sts, ran 1 HE fil sions an	ge, safe ler plug d if th	ety, and for the ca e convent	reliabili nvity in ional mu	ty are the WHB nitions	1
		investigat needed to is warran normally	tions in the ar determine if a ted for convent in the WHB shou	reas of co conventiona tional miss ld be remov	sts, ran 1 HE fil sions an	ge, safe ler plug d if th	ety, and for the ca e convent	reliabili nvity in ional mu	ty are the WHB nitions	

	1 Programme of the Control of the Co	
D00	The INC would contain	the nuclear materials, Dae &
	primary, secondary, IHE, and warhead electrical system.	Its main disadvantage
	is in the large size and heavy weight of the INC.	
CO.X		no4 1

Discussion. These modular warhead designs present some technical development and production difficulties, especially in trying to ensure that the WHB contains no RD. Some low risks face the warhead designers. biggest challenge is to design and produce a highly reliable system that must undergo field insertion. Probably the major challenge is the successful interconnect of the WHD electrical system with the missile fuzing system. course present day Lance and Pershing warheads are field mated to their missiles and they possess high relability. Nevertheless, the INC undergo, in the field, an operation -- the mating of explosives and the pit-that is normally done at a DOE plant. Though reliability may be less. designers are confident of providing a highly reliable system by using proper technology and assuming suitable user training in adverse environments, such as sandy southwest Asia or cold and damp northwest Asia.

- 3. Army Requirements. The Army missions for the analysis are
- Conventional fires to primarily by using submunitions (and perhaps a chemical round) against armored and other tactical vehicles
- Nuclear fires to do the same mission
- Conventional air-defense at medium to high altitude, possibly tactical nuclear ABM defense, and back-up SSM nuclear fires

MU

The AD batteries would generally use a unitary conventional warhead, but these units would also possess a number of missiles that could deliver back-up surface-to-surface nuclear and/or tactical nuclear antiballistic missile (ABM) fires. The field artillery would be dedicated to the ground role, with the capability to deliver nuclear warheads or conventional submunitions (and possibly chemicals). Whether or not these missiles should be convertible in the AD role (unitary conventional or nuclear) and convertible in the field artillery (FA) role (submunition or nuclear) depends upon cost and operational effectiveness trade-offs. We propose a dual-capable missile, however, for two reasons: (1) the greater economics from developing and producing the missile in a joint program and (2) increased survivability through deployment of back-up INCs and SSM missiles to AD units.

Figure V-1 shows the SLSs in peacetime. Fig. V-2 shows these sequences in alert or during wartime.

What are the major differences between the baseline systems and the modular candidate within their SLSs? Table V-I succinctly shows the main differences.

DOD

DOD

Baseline Lance

DOD

Modular convertible SSM/SAM

DOD

Fig. V-1. SLS of Army systems (peacetime).



Baseline Lance (wartime)

DOD

Modular convertible SSM/SAM (alert/wartime)

LIL

Fig. V-2. SLS of Army systems (wartime).

DOD



- 4. Navy Requirements. The Navy missions are:
- Conventional fires against ships, submarines, and shore installations
- Nuclear fires against the above

• Nuclear lifes against the above	
The current baseline system is the a conventional system that	
can be launched from submarines, airplanes, and ships.	Δοί
	D D
$oldsymbol{i}$	
	010
The Phase II and IIA studies presented several design	00
	00
duced with DESTEX, leaving a cavity for insertion of an INC (nuclear applica-	, , ,
tion) or a filler component of additional DESTEX (conventional application).	
Existing ship-board launchers would be used and modified to allow rapid	
change-out of INCs and conventional filler plugs. A safe secure container	
would be built and stored away from the crew to \int	20
For comparative stockpile-to-launch purposes, we con-	
figure an expanded baseline consisting of conventional and dedicated	7
standard nuclear Figure V-3 graphically presents the SLS of the	
Navy system. Table V-II then depicts the differences between the mixed force	
of Harpoons and a modular convertible force.	
5. Air Force Requirements. The Air Force has identified a tactical	
mission of with nuclear munitions. The	
Army and Air Force are currently staffing joint interdiction procedures.	



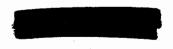


TABLE V-II COMPARISON OF NAVY BASELINE AND MODULAR CANDIDATES

	Procedure	Baseline Conventional Plus Dedicated Nuclear Harpoon	Convertible Harpoon
1.	Production	All-up canisterized conven- tional weapon All-up canisterized nuclear weapon	Force of canisterized missiles with HE (WHB) and emplaced conventional plus
2.	Warhead Transportation and Storage	On missile within canister (conventional and nuclear)	Conventional warhead on missile within canister. INC transported and stored in secure storage container away from canisterized missile and shielded away from crew
3.	Missile Storage	Conventional: In canisters with warheads at storage areas or in ship magazines/launchers Nuclear: In special storage areas or in special ship magazines	Missile stored as conven- tional Harpoon is today
4.	Peacetime Dispersal of WR Warheads	Full-up warheads on missiles in magazines afloat or in special storage	INCs (away from missiles) are in magazines afloat or in special storage areas
5.	Wartime Dispersal of WR Warheads	Onto launchers	Onto launchers; INC inserted into missile
6.	PAL Unlock	Upon message receipt and authentication	Same

An INC TASM could provide a means of increasing weapon survivability if operational procedures and security regulations can be modified (Fig. V-4). An INC separate from the WHB, though still an RD item, is not a nuclear weapon. By dispersing the WHB (less INC) to separate locations in peacetime and storing the INC and its containers in underground storage vaults/wells at both MOBs and COBs, the enemy targeting requirements have risen greatly. Crisis conditions may see the flushing of INCs and exportable shelters to some of the 600 plus airstrips in Europe that can handle F-111 or smaller fighters as eagler

Baseline Gravity Bomb

DOB.

Modular TASM

DOD

Fig. V-4. SLS of Air Force systems.

DCD

C. 'Approach

The summary section at the end of this chapter lists the major advantages, disadvantages, and unknowns that are associated with S^3 , operational effectiveness, logistics, and costs.

TABLE V-III

COMPARISON OF AIR FORCE BASELINE AND MODULAR CANDIDATES

Pol



We have stressed the importance of a favorable regulatory and administrative environment upon the potential utility of the modular candidates. Except for the case of safety where modular weapons are inherently more safe than standard nuclear weapons, a favorable environment is necessary to realize fully the advantages of modular weapons and to minimize the potential disadvantages. Environment is used here in the broadest sense of the word and includes major external factors—political, economic, technical, administrative, or military—that may have an impact upon the three modular candidates.

Combining the advantages and disadvantages intuitively into a decision to proceed or not to proceed with development and engineering is difficult. We provide a simple scheme for aggregating the advantages/disadvantages into an overall quantitative merit value. We then use this scheme to present our quantitative numbers as a guide (see tables at the end of each subsection). The steps in the scheme are:

- (1) Assign a number from zero to three based upon relative evaluation of the value/importance (VI) of each subarea and major area.
 - 0: Unimportant
 - 1: Some importance
 - 2: Very important
 - 3: Extremely important
- (2) Evaluate the utility/worth (U) of the modular warhead as compared to that of the the baseline system in meeting the subarea's requirements.
 - -1.0: Much inferior to baseline
 - -0.5: Inferior to baseline
 - 0: Same as baseline
 - +0.1: Insignificantly better than baseline
 - +0.2: Slightly better than baseline
 - +0.4: Somewhat better than baseline
 - +0.5: Better than baseline
 - +0.7: Substantially better than baseline
 - +1.0: Much better than baseline
- (3) As a conclusion to each major area (for example Safety) discussion, calculate the average merit for all subareas (N in quantity) within that major area.
- (4) Repeat step 3, above, to aggregate all major areas into a final worth.



$$\frac{\sum_{i=1}^{N} \left(VI_{i} \times U_{i}\right)}{\sum_{i=1}^{N} VI_{i}}$$

D. Safety

. *___

Safety is the prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. We distinguish between two types of safety: (1) nuclear detonation safety where an inadvertent detonation gives a nuclear yield in excess of four pounds HE equivalent and (2) plutonium-scatter safety where detonation of the HE results in dispersion of plutonium. Even in an unfavorable regulatory and administrative environment, modular warheads engender increased safety levels.

1. Nuclear Detonation

a. Statement

Separation of explosives from nuclear material inherently increases nuclear detonation safety. (All three candidates)

- Before insertion, modular warheads are safer than the baseline nuclear warheads.
- After insertion, modular warheads are as safe as baseline nuclear warheads.

b. Discussion

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs--the U.S. has a perfect record. However, modular warheads are <u>safer</u> before insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero. After the INC is inserted into the WHB, the modular warhead candidates are as safe as the baseline warheads and can meet the stringent military requirements. INCs would incorporate modern safety features such as weak-link/strong-link circuits and would be stored in safe secure containers. The Army and Air Force candidates would use IHE; the Navy would use DESTEX for their convertible system.

As an example for the first merit estimation and to indicate our logic, we rate the VI of nuclear detonation safety as 3 (extremely important). Compared





to the baseline systems which already afford high nuclear detonation safety, we assign a U of +0.2 (slightly better than baseline).

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+0.2	+0.6

2. Plutonium-Dispersal

a. Statement

Accidents involve lower probabilities of plutonium dispersal. (All three candidates)

b. Discussion.

The two accidents at Thule, Greenland; and Palomares, Spain, in the 1960's required significant cleanup operations and caused much greater political results (such as changes to B-52 alert operations). Future accidents that cause plutonium scatter, especially if in populated areas, could create tremendous problems. The use of IHE for some of our stockpiled weapons has greatly reduced some of these concerns. Nevertheless, the sheer number of nuclear weapon movements leaves the door open for future plutonium dispersal accidents. An accident involving the movement of a WHB (less INC) would not disperse plutonium (it has none) nor should it be called a nuclear weapon accident or incident. An accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs. This is because the IHE used in the INC is minimal. Also, the secure container could generally be stronger than the shipping containers and canisters of the baseline systems, meaning less chance for rupture.

c. Merit Estimation

Candidate	<u>vi</u>	U	VI x U
A, N, AF	3	+0.4	+1.2

3. Intrinsic Radiation

a. Statement

Intrinsic radiation concerns can be lessened by storing INCs in shielded containers. (Navy)

Intrinsic radiation concerns are increased because of greater amounts of nuclear materials in the INCs if shielding is not adequate. (Navy)





b. Discussion

The proximity between crew living and working quarters aboard Navy ships and particularly submarines is a real health concern. In some cases aboard submarines, the crews "live" on top of the nuclear weapons. Intrinsic radiation from nuclear warheads might subject crews to levels above that permitted by medical regulations. An all-up nuclear canistered Harpoon is not easily shielded or stored away from crews; a small INC is. Already shielded by its container, additional shielding can be easily provided to the INC because of its small volume. The second concern deals with exposures when handling the INC out of its container. The time intervals are so short that the radiation effect is minimal. Finally, intrinsic radiation concerns are of much smaller magnitude in the Army and Air Force considerations because of personnel separation from the nuclear munition.

c. Merit Estimation

Candidate	VI	<u>U</u>	VI x U
, N .	2	+1	+2
A, AF	0	+1	0

4. Total and Average Merit Under Safety.

Candidate	Total Merit	Average Merit
A	+1.8	+0.3 (somewhat better than baseline)
N	+3.8	+0.5 (better than baseline)
AF	+1.8	+0.3 (somewhat better than baseline)

E. Security

We define security as a condition that results from the establishment of measures to protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. Several technical and operational advantages accrue to modular warheads.

1. Command and Control

a. Statement

Command and control requirements are now on components that are individually unable to produce a nuclear yield. (All three candidates)

b. Discussion

Command and control is defined as those features that limit warhead use only to authorized personnel during circumstances specifically designated by





proper authority. Baseline systems are protected by PALs and are stored in special nuclear storage areas. One of the reasons for this is the fact that the baseline nuclear round is a full-up nuclear round. An INC in its secure storage container (with PAL, etc.) and the WHB are <u>not</u> full-up rounds by themselves.

c.	Merit	Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+0.7	+1.4

2. Nonviolent Disablement

a. Statement

Nonviolent disablement measures are more compatible with a secure container than a full-up munition or missile. (All three candidates)

b. Discussion

DOD | DOE | b(3)

c.	Merit Estimation			
	Candidate	VI	U	VI x U
	A. N. AF	1	+0.2	+0.2

3. Emergency Destruct

a. Statement

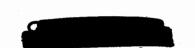
Emergency destruct of nuclear capability and design information is more readily conducted within the secure container. (All three candidates)

b. Discussion

tol

the

greater quantities of HE make the probability of plutonium dispersal greater than zero. However, design information may still be inferred. The modular candidates would have their INCs stored in a command-destruct secure container. It would be so designed as to contain the destruction of the INC, maintain its integrity, and yet eliminate design information.







LOU

c. Merit Estimation

Candidate
A. N. AF

 $\frac{VI}{2}$

U +0.7 VI x U

4. Safe Secure Container

a. Statement

The safe secure container is virtually secure and reduces concerns for HE protection. (All three candidates)

b. Discussion

DOEPED.

DOE P(3)

c. Merit Estimation

Candidate
A. N. AF

<u>VI</u>

+1

VI x U +1

5. Vulnerability to Theft

a. Statement

DOE 6(3)

b. Discussion

The INC within its container, while not portable by a single man, is certainly easier to move than a missile, W81 or W70 warhead, or B57 or B61 bomb. This particularly may apply to the Army candidate and to a lesser extent the Air Force and the Navy candidates, according to the number of sites

and potential exposure to security threats.

DOU NOF

(b)(3)

may do wonders for security but it has a negative impact upon operational effectiveness and survivability.

*	c. Merit Estimation			
	Candidate	VI	U	VI x U
•	A	2	-0.4	-0.8
	N	1	-0.2	-0.2
	AF	2	-0.4	-0.8

6. Peacetime Dispersal

a. Statement

Peacetime dispersal to using units (Army) or deployment during crises/hostilities to collocated air bases or strips (Air Force) for increased survivability means:

- Exposure to more personnel
- Storage at less secure areas than the baseline unless storage wells or exportable shelters are provided

b. Discussion

By personnel, we mean authorized and unauthorized military plus civil-

DOJ



Storage aboard Navy ships and submarines would also be modified to account for shielding of the INC containers and storage away from the crew. The negative impact of dispersal upon Naval security should be very small.

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	-0.4	-0.8
AF	2	-0.4	-0.8
N .	. 1	-0.1	-0.1

7. Total and Average Merit Under Security

<u>Candidate</u>	Total Merit	Average Merit
A	+2.4	+0.2 (slightly better than baseline)
N	+3.7	+0.5 (better than baseline)
AF	+2.4	+0.2 (slightly better than baseline)

F. Survivability

Enemy Targeting

a. Statement

b. Discussion



Dois



DOD

c. Merit Estimation

	<u> </u>		
Candidate	<u>VI</u>	<u>U</u>	VI x U
A	3	+1	+3
AF	3	+1	+3
N	3	+0 1	+ 0 3

- 2. Nuclear Signature
- a. Statement

Dob

BOD

b. Discussion

IC



We do not see differences for the modular Navy system.

c. Merit Estimation

Candidate	<u>v</u> 1	<u>U</u> - 1	VI x U
A, AF	3	+1	+3
N	7	0	0

3. Deployability

a. Statement

INCs can be rapidly deployed to alternate locations during wartime. (All three candidates)

Discussion

and

c. Merit Estimation

	_		
Candidate	VI	U	VI x U
A	2	+0.5	+1.0
AF	2	+0.5	+1.0
N ·	1	+0.2	+0.2

4. Concealability

Statement

INCs are less visible and more easily concealed. (Army, Air Force)



6. Insertion Times

a. Statement

Insertion of the INC into the warhead body requires time. (All three candidates)

b. Discussion



c. Merit Estimation			
Candidate	<u>VI</u>	U	VI x U
N, AF	1	-0.4	-0.4
Α	1	-1.0	-1.0

7. Total and Average Merit Under Survivability

Candidate	Total Merit	Average Merit
A	+8.0	+0.6 (substantially better than baseline)
N	+1.1	+0.1 (insignificantly better than baseline)
AF	+7.6	+0.6 (substantially better than baseline)

G. Operational Effectiveness

Broadly defined, operational effectiveness means the capability of a system to perform the missions or functions for which it is designed. This definition could then include survivability and security. To limit the scope, we narrow operational effectiveness to include mobility, targeting flexibility, enduring capability, storage flexibility, nuclear yield, conventional warhead effects, reliability, range, and foreign political acceptability. The three candidates generally offer improvements over the baseline systems in this area.

1. Mobility

a. Statement

Strategic and tactical mobility for European and special theaters are increased because of the small size and weight of INCs and lack of nuclear materials in the WHB. (All three candidates)



b. Discussion

The baseline nuclear weapons constrain the defense transportation system in its ability to move the weapons rapidly in large numbers. Part of the reason is physical: The baseline nuclear warheads are larger, weigh more than the INCs, and contain significant amounts of SNM next to a large amount of HE. The other part is political: The baseline warheads are full-up nuclear rounds. For example:

(1) Strategic mobility suffers because

DOD

(2) Tactical mobility also suffers because

DOD

At the risk of overt repetition,

c. Merit Estimation

 Candidate
 VI
 U
 VI x U

 A, N, AF
 3
 +1
 +3

- 2. Targeting Flexibility
- a. Statement

DOM

W.

c. Meri	t Estimatio	<u>n</u>		
Can	didate	<u> VI</u>	<u> </u>	VI x U
	A	. 2	+0.5	+1
	N	3	+1.0	+3
	AF	1	0	O (not convertible)

Enduring Capability

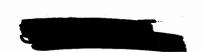
a. Statement

Enduring capability is available through the rapid logistical resupply of INCs. (All three candidates)

b. Discussion



120



surviving missiles and WHBs than the resupply of a full-up nuclear warhead and missile.

The advantages to the Air Force dedicated TASM are not as large. The number of missiles and WHBs will equal the number of INCs as this is not a convertible candidate. Nevertheless, loss of an INC without concomitant loss of WHBs and missiles will make resupply of INCs stockpiled out of theater easier than resupply of a full-up baseline gravity bomb.

c. Merit Estimation

Candidate	<u>VI</u>	<u>U</u>	VI x U
A, N	2	+0.7	+1.4
AF	2	+0.4	+0.8

4. Storage Flexibility

a. Statement

Convertible weapons allow full nuclear or conventional capabilities where storage areas are limited. (Navy)

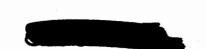
b. Discussion

c. Merit Estimation

Candidate	VI	<u>U</u>	VI x U
N	-3	+1	+3
A, AF	0	0	0

Nuclear Yield

a. Statement



b. Discussion

Secondary missions for the Army SSM and Air Force TASM modular candidates might require destruction of relatively hard fixed targets. This more probably would be the case for the Air Force in its interdiction mission. If these fixed-target requirements are imposed, and other nuclear systems (B61 gravity bomb, GLCM, Pershing IA or II) are not deemed sufficient to cover this target set, then we would strongly recommend the development of a terminal correlation module to be used by some of the SSMs and/or TASMs to get CEPs down to about 30 meters.

· DOE bC

IOL

DOE 6

DOD

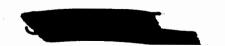
It would be heavy, cumbersome, and difficult

to nandle. Many of the advantages that we discussed earlier would erode or disappear. To minimize the impact, assign the mission to only one of the services, say the Air Force, and assign only a part of the TASM force (and use a full-up nuclear munition instead of a modular one). Keep the remaining TASM force modular with one-stage INCs.

The merit numbers below assume that the Air Force is assigned the additional fixed-target mission and either builds only part of the TASM force with INCs (the rest are two-stage standard TASMs) or builds additional GLCMs and/or B61s. The yields of the Army candidate would then be sufficient.

c. Merit Estimation

Candidate	<u>vi</u>	<u>U</u>	VI x U
AF	3	-0.5	-1.5
A,N	3	0	0





6. Conventional Warhead Effects

a. Statement

Convertible weapons may incur reduced conventional effectiveness because of WHB body volume devoted to the nuclear application. (Army, Navy)

b. Discussion

Do E b(3)

A conventional filler plug could be developed, but this would require careful study of the trade-offs between increased effectiveness versus the logistic effect of another component upon the STSs.

The Army's problem is more serious with regard to its conventional SSM role (no major implications are seen in the SAM role which uses a unitary HE warhead). This mission of conventionally stopping the enemy second-echelon forces requires the use of submunitions.

000

This volume is lost to submunitions and may make the convertible SSM ineffective and too costly. If so, the dual-purpose SSM/SAM should still receive consideration for AD batteries, although the field artillery batteries would then have both full-up conventional SSMs and dedicated modular nuclear SSMs.

c. Merit Estimation

Candidate	<u>VI</u>	<u>U</u>	VI x U
N	2	-0.1	-0.2
A	2	-0.5	-1.0
AF	0	0	0

Reliability

a. Statement

A reliability degradation is expected. This can be minimal with the use of high production standards, affordable because of the small weapon system buys, and fully acceptable, especially in insertion operations within a clean environment. (All three candidates)

b. Discussion





DOC 1.0.

, **....**

7 13 F

The convertible warheads, when used conventionally, intuitively should have reliabilities almost identical to the conventional baseline systems. This is normally driven by the reliability of the missile. The cavity within the WHB itself can be designed to have a negligible reliability effect.

Reliability of the modular candidates when used in a nuclear mission is of greater concern, particularly when mated to a convertible missile that is produced with reliability levels acceptable just to conventional applications. The cost of building and certifying all the missiles and WHBs to reliability levels necessary for nuclear use will have to be incurred whether the missile system application is nuclear-only or convertible. Since the candidates are all relatively low-buy, high-value munitions, this cost should be relatively small over the total life cycle.

Reliability of the INC built at the DOE production plants, however, should still be very high. A good and simple one-stage design that underwent adequate development, testing, and production, would seem to ensure a very high reliability. In the field, the sealed INC would undergo simple electrical checks to ensure its positive status. The real question is the successful ability to insert the INC, ensure that the proper electrical interfaces have been made, check the overall weapon status, and then be ready to launch a reliable missile, all within about 15 minutes. One can imagine a very difficult environment—dry insertion in rolling seas and pitching decks or on a dark, rainy, dirty, muddy battlefield; or a rather benign environment—a shelter at a collocated Air Force base. One should keep in mind, however, that today the current Lance and Pershing 1A missiles require a physical and electrical mating of the nuclear warhead in field environments.

We think that good operational procedures can result in modular warheads with at best reliability as high as the baseline nuclear warheads, and at worst a slight degradation that is fully acceptable (especially in light of the lower <u>missile</u> reliability). But pending actual reliability testing of mockups and WR warheads, and given the reliability of the missile itself, we conservatively take a pessimistic view in the merit analysis with regard to system reliability.

UNCLASSIFIED

 \prec

c. Merit Estimation

Candidate	VI	U	VI x U
A	3	-0.7	-2.1
N	3	-0.5	-1.5
AF	3	-0.2	-0.6

8. Range

a. Statement

Range for the nuclear mode of convertible weapons may be less. (Army)

b. Discussion

The Navy convertible system is not range-affected because the convertible and nuclear applications

DOD

The Army system, however, may or may not carry the submunitions in a nuclear role. Downloading the submunitions would give a full nuclear range, but at a cost of time and affecting survivability, operational effectiveness, and logistics. Again, it may be more cost-effective, as noted above, to have a dedicated modular SSM for the nuclear mission instead of a convertible.

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	0	0
A	2	-0.5	-1.0
AF	2	0	0

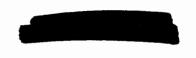
9. Deployability

a. Statement

D00

b. Discussion

DOD



The perception of this rationale by the political leaders and populous of the host nations may be the exact opposite of this study's perception. They may believe instead that "a nuclear weapon is a nuclear weapon..." We have no idea as to the merit of modular warheads as related to these concerns except that there is now a possibility of storing, docking, and overflying modular warheads, while there is not with the baseline systems.

10. Total and Average Merit Under Operational Effectiveness

Candidate	Total Merit	Average Merit
A	+1.3	+0.1 (insignificantly better than baseline)
N	+8.7	+0.4 (somewhat better than baseline)
AF	+1.7	+0.1 (insignificantly better than baseline)

H. Logistics

The broad area of logistics includes transporation and handling, storage requirements, training, special theater movements, LLCE complexity and intervals, administrative and security regulations, component classification, maintenance and support, security personnel and storage sites, and personnel reliability and inspections. We find that in the area of logistics each of the three candidates show potential improvements over the baseline, albeit small in degree in the aggregate.

- 1. Transportation and Handling
- a. Statement

DO E 6C

D. UISCUSSION

Significant advantages accrue in the normal day-to-day logistical transportation and handling of INCs. The INCs can be moved easily by air or ground shipment. Convoy sizes can be reduced in numbers of vehicles and personnel because of the lower physical transportation requirements and the inherent safety of INCs. Likewise, transportation costs for initial deployment and operational and maintenance movements during the warhead's life should fall dramatically.

c.	Meri	t Es	timat	ion

Candidate	VI	<u>_U</u>	U x IV
A, N, AF	2	+1	+2





2. Storage Requirements

a. Statement

The size of storage areas requiring special protection is decreased. (All three candidates)

b. Discussion

Our premise is that only the INC will contain RD information. Unlike the baseline nuclear munitions that require special nuclear storage of the entire nuclear warhead or an entire nuclear warhead mated to its missile, the nuclear storage requirements of INCs are minimal, whether it be at Army special storage sites or barracks arms rooms, Navy special magazines, or Air Force special storage sites and MOBs/COBs.

c. Merit Estimation

Candidate	VI	<u>_U</u>	VI x U
A, N, AF	2	+1	+2

3. Training

a. Statement

Training in unit areas and in the field can improve because of the greater availability of INC mock-up trainers and non-RD warheads. (All three candidates)

b. Discussion

The availability of training devices for the baseline munitions is limited. This limitation, plus the size and weight of the trainers, restricts the quantity and quality of hands-on training.

This problem is particularly acute for the Army baseline system. Though alert exercises train and test the units in their ability to move from the barracks environment to a full field environment.

DOM:

The design of the INCS

allows for the production of numerous cheap trainers. By having these trainers at the firing unit area, the soldiers during peacetime can receive excellent training in their use by deploying to the field with their missiles, WHBs bodies (drawn from conventional ASPs), and INC trainers. The artillerymen can then train in the insertion of the INCS in the field.





Many of the same benefits accrue to the realistic training for the Navy and Air Force modular candidates. Greater availability of trainers and practice exercises can do much to alleviate the reliability problems and time requirements that we examined previously.

c. Merit Estimation

<u>Candidate</u>	VI	<u>U</u>	U x IV
A, N, AF	2	+1	+2

4. Special Theater Movements

a. Statement

Transportation of INCs into special theaters can be more rapid and secure than full-up nuclear munitions. (All three candidates)

b. Discussion

c. Merit Estimation

Candidate	17	<u>_U</u>	VI x U
A, AF	3	+1	+3
N:	2	+1	+2

Limited-Life Component Exchange (LLCE) Complexity

a. Statement

Limited-life component exchange is easier. (All three candidates)

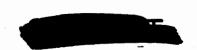
b. Discussion

DOD

This operation has a DOE bC

7.7

sizeable impact upon logistic efforts and operational readiness.







The small size and weight of INCs plus their greater accessibility for maintenance is an advantage over the baseline system. The change-out process can be conducted more rapidly and with less maintenance man-hours.

Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+1	+1

6. Administrative and Security Regulations

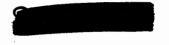
a. Statement

Administrative and security regulations <u>must</u> be adapted to engender viability of modular weapons in all utility areas (except safety, which is inherently increased). (All three candidates)

b. Discussion

The overall utility to be derived from the candidate modular systems largely depends upon modifying current administrative and security regulations. Current restrictions come mainly from the DoD Directive on security criteria. As currently written, this policy means that all components of a modular warhead would inherit the same restrictions as the baseline nuclear systems: two-man rule, large security forces, substantial storage requirements, and concentrated storage at special sites.

We think that our preferred one-stage design approach can satisfy all the safety and security objectives behind current administrative regulations within the SLSs sequences noted previously. We also believe that the intent of the regulations and directives can be fully satisfied by using the modular newly adapted set of regulations under and Nevertheless, we recognize that institutional inertia within the security community (which is common to all large organizations) to keep the same administrative and logistic systems must be overcome. Probably the best way is to provide mock-up point designs (paralleling the DOE Phase 2 and 3 efforts) to the safety, security, and logistic experts who would determine acceptability and work out these modifications. Evolutionary change of these regulations is the only forseeable path that is politically acceptable at this Nevertheless, failure to adapt regulations to account for the singular differences of modular weapons from those of standard nuclear weapons would result in disutility greater than that indicated by the merit estimation in this subarea.



c. Merit Estimation

Candidate
A, N, AF

<u>VI</u>

<u>U</u> -1 AI × n

7. Component Classification

a. Statement

The WHB body <u>must not</u> carry a classification higher than its delivery missile. (All three candidates)

b. Discussion

This concern parallels the one above, but needs to be spelled out to allow early field and collocated base deployment of the Army and Air Force candidates.

Current classification is:

DIE DIE 63)

Doe b

This is not critical since it will be on a secure container for most of its life.

DOE b





This is not to say that NCA release and reliable secure communications will no longer be needed to insert the RD INC into the WHB. Sealed authenticators will still be required along with PAL devices on the INC container and even possibly on the complete warhead system after release is granted.

c. Merit Estimation

Candidate	<u>VI</u>	<u> </u>	VI x U
A, N, AF	3	-1	-3

8. Maintenance and Support

a. Statement

Maintenance and support workload and handling equipment are reduced for the INC. (All three candidates)

b. Discussion

A primary logistic consideration is maintenance. The one-stage design approach should mean that the using unit would only need to make visual inspection and simple electrical checks to ensure that no unauthorized actions By keeping the design of the WHB body and INC as simple as had occurred. possible, maintenance workload should be reduced because of easier access and less sophisticated tests. Normal stockpile maintenance and testing of the interfaces between the explosives and warhead electrical system would be eliminated until mating of the INC occurs during war. Large handling equipment requirements would no longer exist for maintenance of the INC because of its The Navy candidate may also result in some maintenance (and small size. transportation) reduction by not having to send the whole canistered nuclear Harpoon back to depot as the baseline system requires. The dispersal of Army INCs to unit arms rooms (or within security wells, safes, etc.) might require transient maintenance sections to visit the dispersed locations. However, the reduction in workload at the special nuclear sites should offset the personnel requirements for the transient sections. Another alternative is to assign these "go/no-go" checks to the operational crew at the firing units.

Maintenance may rise, however, because additional equipment will be deployed for modular warhead support:

Army INC containers, secure storage at firing batteries (wells, safes, etc.), test equipment

Navy INC containers, test equipment





Air Force INC containers, deployable secure storage assets (transporters, moveable igloos, etc.), test equipment

Additional procedures and administrative guidance would be needed. The modular systems would require their own checklists, repair parts, and special tools.

c. Merit Estimation

Candidate	VI	<u>U</u>	VI x U
A	2	+0.2	+0.4
N, AF	2	+0.4	+0.8

9. Security Personnel and Storage Sites

a. Statement

Numbers of security personnel will generally be unchanged unless current storage sites become INC-only sites. However, security personnel requirements and storage sites will increase if unit storage is allowed. (Army, Air Force)

b. Discussion

As long as the number of storage sites remain constant and include baseline nuclear weapons, then the number of guards will remain unchanged.

The use of the Army modular candidate would cause the dispersion of SSM INCs away from current fixed sites into the arms rooms of the firing units. The fixed sites, however, would still require protection for the AFAPs, ADMs, and Pershings. We see no hope for reductions in guard forces at these sites, unless these sites are consolidated (with a loss of survivability) or some weapons are removed back to CONUS. An argument can be made that security forces may increase, as the quantity and quality of arms rooms guards might be insufficient. Given current FA and AD artillery TOEs, this concern is a valid one.

Security manning for the Navy modular system afloat would remain the same. Peacetime security for the Air Force system would also parallel present requirements; however, crisis deployment to COBs and/or airstrips would have to draw on additional personnel.

Security during normal peacetime transportation movements could be reduced as noted earlier. Convoy security force requirements (infantry units) are substantial and detract from normal training.





c. Merit Estimation

andidate_	<u>vi</u>
A, AF	2
N	3

VI	x	U	
	١.4	1	•
(1		

10. Personnel Reliability and Inspections

a. Statement

Requirements for personnel reliability programs and inspections will probably remain the same. (All three candidates)

b. Discussion

The same high level of personnel competence that currently exists for the baseline warhead systems would apply to the modular candidates. Personnel involved in the authentication system and insertion of the nuclear component would still remain in critical nuclear duty positions. Those involved in the security of the INC would still be in controlled nuclear duty positions. The need for records, operational procedures, and maintenance would have an impact on the three modular candidates to the same degree as it presently does.

c. Merit Estimation

Candidate	VI	<u>u</u>	VI x U
A, N, AF	2	0	0

11. LLCE Intervals

a. Statement

LLCE intervals and stockpile life will remain the same. (All three candidates)

b. Discussion

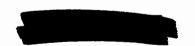
No differences can be identified between the modular warhead candidates and the baseline nuclear systems in regard to LLCE intervals or stockpile life.

c. Merit Estimation

Candidate	<u>vi</u>	<u>U</u>	VI x U
A, N, AF	· 1	0	0

12. Total and Average Merit Under Logistics

<u>Candidate</u>	Total Merit	Average Merit		
A	+3.0	+0.1 (insignificantly better than baseline)		
N	+3.8	+0.2 (slightly better than baseline)		
AF	+3.4	+0.2 (slightly better than baseline)		



c. Merit Estimation

 Candidate
 VI
 U
 VI x U

 N
 3
 +1
 +3

 A, AF
 N/A

2. SNM Requirements

a. Statement

Convertible warheads require slightly higher amount of SNMs than non-convertible warheads of the same yields. Nuclear-only INC warheads, however, are about as efficient in the use of SNM as standard nuclear warheads. (All three candidates)

b. Discussion

Previous studies have indicated that INC warheads require more SNM than standard warheads, all other things being equal. 1000

Two resource considerations also apply to SNM usage--cost and supply/demand. The costs are set by decree and may not reflect SNM's true value.

DOE, b(3)

106

DOE 6(3)

Doo



DOI

Clearly, major changes in RD&T costs have little impact upon life-cycle cost. With a straightforward simple design, nuclear testing can be held to a minimum. We do not foresee much change in RD&T costs as compared to baseline nuclear system costs.

DOL

Production costs for the warheads (DOE and DoD) may show some additional cost expenditures over the baseline systems. This is due to producing a "different" type of warhead. New tooling and facilities will be necessary. Direct unit costs of manpower and material for the warhead will probably be very similar to the costs of baseline systems. Cost savings may be realized through using a simpler and less expensive final assembly at the Pantex Plant.

c. Merit Estimation

<u>Candidate</u>	<u>vi</u>	U	VI x U
A. N. AF	2	-0.2	-0.4

4. Safe Secure Containers and Storage Facilities

a. Statement

Production of safe secure containers and construction of associated storage facilities may be expensive, particularly for the Army system. (All three candidates)

b. Discussion

As noted in the Harpoon studies, 10,30 the real crux of production cost increases lies in the requirements for safe secure containers (all three modular candidates), construction of new storage facilities (wells, igloos, airtransportable shelters), and secure transporters.

DID

The Navy requirement for this extra equipment is less than the Air Force's or Army's.



000

Perhaps C-130 transportable shelters could be procured, or perhaps C-130 transportable versions of safe, secure trailers could be used. (The TASM with WHB less INCs would be carried by the flushed fighter aircraft).

DOT

c.	Merit Estimation		VI U VI x U -0.2 -0.4 2 -0.4 -0.8		
	Candidate	<u>v1</u>	<u>U</u>	VI x U	
	N	2	-0.2	-0.4	
	AF	2	-0.4	-0.8	
	, A	2	-0.7	-1.4	

5. Missile System Operation and Support Costs

a. Statement

If DOD Missile system operation and support costs account for about weapon total life-cycle costs. (If the delivery unit life-cycle cost is considered, then the cost of INCs becomes practically negligible in terms of total life-cycle cost.) The cost may rise in certain areas and fall in others. The overall effect is highly dependent upon INC storage schemes and security regulations, especially for the Army system. (All three candidates)

Discussion

Operation and support include the areas of security, maintenance, transportation, reliability testing, and staff support. As noted previously, about DOD of the life-cycle cost is for operation and support and operation and support costs are security related. The impact upon operation and support costs by the modular candidates will be a function of the percentage of stockpile that is converted to modular systems, the distribution of them among storage sites, and the type of storage and operational concepts adopted.

DOD

DOE

UNCLASSIFIED

109

DOE (3)

DOC

Transportation is one operation and support area where significant savings should be realized. First- and second-destination transportation, operational moves, and transportation to depot for maintenance are expensive in dollars and transportation assets. Convoy sizes and aircraft sortic requirements can fall greatly because of the small INC volume and weight, and the inherent safety and

security by having the nuclear material separate from the main explosives.

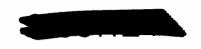
Reliability testing and stockpile support will probably remain the same.

c. Merit Estimation

For the merit analysis, we use the relative importance of each subcategory:

Candidate	ΛI	U	VI x U
Security			
A	2	-1.0	-2.0
N	2	0	0
AF	2	-0.5	-1.0





Maintenance		•	
A :	1	-0.5	-0.5
N	1	0	0
AF	1	0	0
Transportation			
A, N, AF	1	+1.0	+1.0
Reliability Testing/ Staff Support			
A, N, AF	1	0	. 0

6. Total and Average Merit Under Costs

Again for the merit analysis, we use the relative importance of each cost category.

Candidate	Total Merit	Average Merit	
Α	-3.7	-0.3 (somewhat worse than baseline)	
*N	+2.8	+0.2 (slightly better than baseline)	
AF	-1.6	-0.2 (slightly worse than baseline)	

^{*}Fewer modular missiles procured because of convertibility.

J. Summary Merit Analyses

Preceding sections have described the advantages and disadvantages of the three modular weapon candidates. At the end of each section we summarized the quantitative merit based upon the analyzed information. For convenience, the data on average merit are presented below.

Area/Candidate	VI	Army	Navy	Air Force
Safety	2	+0.3	+0.5	+0.3
Security	2	+0.2	+0.5	+0.2
Survivability	3	+0.6	+0.1	+0.6
Operational Effectiveness	1	+0.1	+0.4	+0.1
Logistics	1	+0.1	+0.2	+0.2
Costs	1	-0.3	+0.2	-0.2

By combining the major area average merits, we can arrive at a summary ranking that is useful for comparison between the modular candidates themselves and for comparisons between the baseline weapon systems. First we must





rank the worth of the areas; then we must carry out the simple math. We maintain that the area of survivability is of overriding importance, and we assign a VI of 3, or "extremely important". We rank safety and security next with a VI of 2, or "very important." Operational effectiveness, logistics, and costs are considered to be of "some importance" and are assigned a VI of 1. We arrive at the following figures by multiplying the VI times the average merit for each area, sum the six areas, and divide by the sum of the VIs (10).

Candidate	Average Merit			
A	+0.27 (somewhat better than baseline)			
N	+0.31 (somewhat better than baseline)			
AF	+0.29 (somewhat better than baseline)			

There is a striking similarity in average merit between the modular candidates, perhaps because they all have tactical missions and many subareas show utility regardless of the application (for example, plutonium-scatter safety). All three candidates display good potential towards improving the tactical nuclear stockpile; any or all bear continued consideration for addition to the inventory.



CHAPTER VI

REVIEW OF PERTINENT REGULATIONS AND DIRECTIVES

A. General

Providing for safety in handling nuclear weapons is a joint responsibility of the DoD and DOE. The DoD is also responsible for providing secure custody of the nuclear weapons under its control.



The facilities and procedures prescribed these directives accordingly elaborate by are and substantial resources. The question raised by the possibility of deploying weapons with INCs is whether the required resources for ensuring safety and security could be thereby materially reduced. That question is discussed in this chapter. A bibliography is shown below:

DOD DIRECTIVES

5210.41

Security Criteria and Standards for Protecting Nuclear Weapons

Miscellaneous Publications

JCS Pub. 6, Nuclear Weapons Reports (NWREP)

Vol. II, Part 4

SB 742-1 Ammunition Surveillance Procedures

ARTEP 9-47 Special Ammunition Unit Operations

CG-W-4 Nuclear Weapon Classification Guide

DOE-DNA TP 0-1 Numerical Index to Joint Nuclear Weapons Publications

Department of the Army Publications

Army Regulatio	ns (ARs)
50-5	Nuclear Surety
50-5-1	Nuclear Surety (classified volume to AR 50-5)
50-109	Safety Rules for the Operation of the Lance Nuclear Weapons System
55-203	Movement of Nuclear Weapons, Nuclear Components, and Related Classified Nonnuclear Material





		UINODIZ
	190-11	Physical Security of Weapons, Ammunition, and Explosives
	385-64	Ammunition and Explosives Safety Standards
	700-65	Nuclear Weapons and Nuclear Weapons Material
	Field Manuals (FMs	<u>)</u>
	9-6	Ammunition Service in the Theater of Operations
	9-84	Nuclear Special Ammunition Direct and General Support Unit Operations
	19-30	Physical Security
	100-50	Operations of Nuclear-Capable Units
	Technical Manuals	(TMs)
	9-1300-206	Ammunition and Explosives Standards
	39 -0-1A	Numerical Index to Joint Nuclear Weapons Publications (Army supplement)
	39-20-7	Nuclear Safety Criteria
	39-45-51	Transportation of Nuclear Weapons Material
	39-50-8	Emergency Destruction of Nuclear Weapons
	39-100-4	Custody, Accountability, and Control of Nuclear Weapons and Nuclear Material
	55-1425-485-15-1	Transportability Guidance Lance Missile System
	Technical Bulletin	s_(TBs)
	9-1100-803-15	Army Nuclear Weapons Equipment Records and Reporting Procedures
	9-1100-811-40	Security Classification of Nuclear Weapons Information
	742-94-1	Surveillance Inspection Procedures for Nuclear Weapons
Der	partment of the Navy	Publications
001	OPNAV Instructions	
	8023.2A	U.S. Navy Explosive Safety Policies, Requirements and
	35241	Procedures
	8023.19	Safety Criteria and Standards for the Logistical Move-

Special Weapons Ordnance Publications (SWOPs)

20-7 Nuclear Safety Criteria

45-55 Instructions for Tactical Movement of Ground-Delivered

Navy Nuclear Weapons Safety Program

Nuclear Weapons

ment of Nuclear Weapons





8110.18

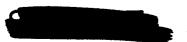


against the presumed disadvantages of making procedural exceptions. The advantages of modular systems are discussed in earlier chapters of this study. Each service would identify for itself the disadvantages of allowing departures from practices that have long been followed in the care and handling of its nuclear weapons.

C. Expectation for Change in Handling Procedures

It does not seem likely that the military services will change their procedures for handling nuclear weapons before a modular system is fielded. Therefore, the first modular system cannot be designed to accommodate changes that will be made in those procedures after the system is fielded, if any such changes are made. It does not appear that the development of modular technology is hindered by present directives or procedures. If modular systems are designed to be handled exclusively in accordance with presently prescribed methods, however, the presumed advantages of fielding such systems will not be fully realized.







The preferred SLS for the Army modular candidate would continue the present practice of deployment of missiles and launchers to survivable field locations during training and alerts. The non-RD WHB would also deploy on the missile with the units.

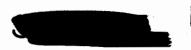
2. Security. Security is a condition that results from the establishment of measures to protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. Several technical and operational advantages of varying importance accrue to modular warheads. The primary operational advantage lies in the fact that, for most of their life, security requirements are on components that are neither full-up nuclear weapons nor able to produce a nuclear yield.

Security Merit Assessment

Army = +0.2 Slightly better than baseline

Navy = +0.5 Better than baseline

Air Force = +0.2 Slightly better than baseline





movements, training, LLCE, administrative and security regulations, component classification, security personnel, and personnel reliability and inspections. Throughout the study we used the SLSs that were defined under a favorable environment and found slight improvements in the three modular candidates.

Logistics Merit Assessment

Army = +0.1 Insignificantly better than baseline

Navy = +0.2 Slightly better than baseline

Air Force = +0.2 Slightly better than baseline

6. Costs. Life-cycle costs including development, production, operation, and support were examined in a relative context. Though absolute cost numbers were not estimated, the merit assessment qualifies the broad cost trends. The Navy's convertible force should cost less than the baseline if fewer Harpoon missiles are procured for the convertible force. The Army and Air Force modular candidates are thought to cost more, primarily because of increases in production, security, and storage costs.

Costs Merit Assessment

Army = -0.3 Somewhat worse than baseline

Navy = +0.2 Slightly better than baseline (fewer modular missiles procured because of convertibility)

Air Force = -0.2 Slightly worse than baseline

7. Merit Assessment Summary

By combining the major area average merits, we can arrive at a summary ranking that is useful for comparisons between the modular candidates themselves and for comparisons between the individual baseline weapon systems. We maintain that the area of survivability is of overriding importance, followed next by safety and security. Operational effectiveness, logistics, and costs are of lesser relative importance.

There is a striking similarity in merit between the modular candidates; all are deemed to be "somewhat better than baseline." The Navy modular candidate gives a summary merit of +0.31, followed closely by the Air Force and Army modular candidates at +0.29 and +0.27, respectively.





C. Recommendations

Increases in survivability should be the primary reason for developing, producing, and deploying modular nuclear warheads. In addition, safety stands out as the single area where INC benefits are unequivocal regardless of the administrative and security environment that evolves for modular warheads. Although the benefits of having safer warheads are of great importance, we realize that modern standard warheads have an unblemished safety record regarding accidental nuclear detonation; however,

The real benefits in safety improvements lie in allowing changes in the transportation and storage of nuclear weapons that can result in greater dispersion and enhanced survivability.

Several earlier studies and the analyses conducted here indicate the potential utility of a modular system. A careful and logical development process for any of the three modular candidates can lead to exploiting the benefits noted while minimizing the disadvantages. Three specific recommendations are made:

- (1) Recommend that the Los Alamos National Laboratory (Los Alamos) develop mockups or point designs for appropriate service generic systems to enable the services to evaluate the operational, logistic, safety, security, survivability, and system cost impacts of INC or convertible systems.
- (2) Recommend that Los Alamos continue to develop concepts for engineering designs to support modular systems in support of identified or perceived service requirements.
- (3) Finally, based upon specific service stated requirements, recommend that Los Alamos be prepared to develop modular warheads for production and employment.





REFERENCES

- "Nuclear Weapon Development Guidance (NWDG) (U)," Department of Defense (SRD) (1972 and 1973).
- "Special Nuclear Technology and Analysis Report (U)," Field Command Defense Nuclear Agency report FC/01750080 (SRD) (January 13, 1975).
- "CASK...A Convertible Anti Ship Killer (U)," Sandia Laboratory at Livermore/Lawrence Livermore Laboratory joint report SCL-SR-720069 (SRD) • (November 1972).
- 4. '"Phase 1 Warhead Study for the MK 48 Torpedo (U)," Los Alamos Scientific Laboratory/Lawrence Livermore Laboratory/Sandia Laboratories joint report SC-WD-72 0625 (SRD) (August 1972).
- 5. LCDR G. F. Nolan, "A New Weapon Concept (U), Insertable-Nuclear Component Concept (CFRD)," Field Command Defense Nuclear Agency (CFRD) (May 1, 1974).
- "Phase 2 Feasibility Study for Atomic Demolition Munitions (U)," U.S. Army Armament Command report 74-8 (SRD) (June 30, 1974).
- 7. R. R. Hammond, "Navy/ERDA Phase 1 Study of Lightweight Torpedo Warhead Improvements (U), " Naval Undersea Center report NUC TP 458 (SRD) (February 1975).
- 8. L. E. Thompson, "Phase 1 Study for a Nuclear Harpoon (U)," Naval Weapons Center report NWC TP 5891 (SRD) (September 1977).
- 9. "Phase 2 Feasibility Study for a Nuclear Harpoon (U)," Naval Weapons Center report 407/5362/MS 76-145 (SRD) (September 1976).
- "Joint ERDA/Navy Technical Report of the Nuclear Harpoon Phase 2A Study (U)," prepared by Naval Weapons Center for Naval Air Systems Command, report NWC TM 3303 (SRD) (September 1977).
 Volume 1. "Technical Summary (U)"

Volume 2. "Warhead/Physics Designs (U)"

Volume 3. "Safing, Arming, Firing and Fuzing Designs (U)"

- 11. "Convertible Concepts for the MK 84." Air Force Weapons Laboratory (SRD) (August 1976).
- 12. H. J. Gevelhoff, M. R. Anderberg, W. M. Boyer, J. A. Higgins, K. Hinkle, H. A. Kuerschner, B. J. Manz, and J. H. Suttle, "A Utility Analysis of Convertible Nuclear Weapons Executive Summary (U)," Directorate of Aerospace Studies report SA-TR-75-4 (SRD) (March 1975).
- H. J. Gevelhoff, Study Director, "A Utility Analysis of Convertible Nuclear Weapons (U)," Directorate of Aerospace Studies report DAS-TR-76-3 (SRD) (April 1976).

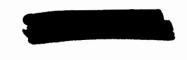




- 14. COL M. B. Sullivan, LtCol C. S. Lee, et al., "Nuclear Convertibility for the Harpoon Missile, An Analysis (U)," Field Command Defense Nuclear Agency report FC/03750148 (SRD) (March 7, 1975).
- 15. LtCol G. F. Pitstick and Capt S. C. Mauk, "Phase 1 Study for the Modular Guided Glide Bomb (MGGB)," Air Force Weapons Laboratory report 73-SAA-079 (SRD) (August 1973).
- C. I. Hudson, Jr., and D. E. Warne, "INC Weapon Technology Applications Study-Review of Weapon Systems and Selection of Candidates (U)." prepared by Science Applications Inc., La Jolla, for Defense Nuclear Agency, report DNA 3770F (SRD) (August 31, 1975).
- 17. "INC Weapon Technology Application Study Second Part, Detailed Assessment and Economic Analysis (U)," prepared by Science Applications, Inc., La Lolla, for Defense Nuclear Agency, report DNA-4121 F (SRD) (September 1976).
- 18. L. M. Redman, "LASL Weapons Quarterly (U)," covering January-March 1977, Los Alamos Scientific Laboratory report LA-6830-PR (SRD) (May 1977).
- 19. E. L. DuBois, "Implications for Theater Nuclear Forces of a Design Concept Using Separable Nuclear Components (U)," prepared by SRI International, Menlo Park, for Lawrence Livermore Laboratory, report UCRL 15244 (SRD) (September 1979).
- 20. Dr. H. J. Gevelhoff et al., "Utility Evaluation of Stand-Off Missile Candidates, An Annotated Briefing of the Executive Summary," Directorate of Aerospace Studies report DAS-TR-77-16 (SRD) (October 1977).
- 21. Dr. B. J. Manz, "Utility Evaluation of Stand-Off Missile Candidates, Volume 3 Military Effectiveness," Directorate of Aerospace Studies report DAS-TR-78-6 (SRD) (August 1978).
- 22. J. K. Hayes and J. S. Howard II, "Utility Analyses for a Tactical Air-to-Surface Munition (TASM) (U)," Los Alamos National Laboratory report LA-8543-MS (SRD) (April 1981).
- 23. "Compendium of Convertible Technology (U)," Naval Weapons Center report NWC TM 4646 (SRD) (August 1981).
- 24. "Corps Support Weapon System (CSWS) Insertable Nuclear Component (INC) Study," U.S. Army Nuclear and Chemical Agency draft report (SRD) (June 30, 1982).
- 25. R. L. Wagner, "Nuclear Weapons Technology: Insertable Nuclear Components (U)", SRD memorandum from the Assistant to the Secretary of Defense (Atomic Energy) for the Assistant Secretary of Defense (International Security Policy), December 29, 1981.
- 26. A. R. Cole, "Insertable Nuclear Components (U)," SRD TWX 000383 from DOE/MA to Distribution, June 3, 1982.



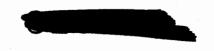
- 27. T. B. Hayward, "Insertable Nuclear Component Policy (U)," SFRD memorandum from Admiral, U.S. Navy, Chief of Naval Operations to Distribution, Ser 00/S500207 May 7, 1980.
- 28. R. L. Anderson and C. H. Blummenfield, "An Analysis--The Suitability of Insertable Nuclear Capsules for an Army Multi-Purpose, Close Support Missile System (U)," Los Alamos National Laboratory internal document WPC-2-78-52 (SFRD) (July 5, 1978).
- 29. "Security Criteria and Standards for Protecting Nuclear Weapons (U), DoD Dir 5210.41 (U) (September 12, 1978).
- 30. COL M. B. Sullivan, LtCol C. S Lee et al., "Nuclear Convertibility for the Harpoon Missile, Executive Summary (U)," Field Command Defense Nuclear Agency report FC/03750149 (SRD) (March 7, 1975).
- 31. Capt T. Alpert, Maj R. Case, LTC D. Fowler, LCDR R. Gordon, LCDR G. Kouba, MAJ T. Mills, LtCol J. Munson, and LTC K. Zahn, "DoD Nuclear Stockpile Operating and Support Costs, Volume I Executive Summary (U)," Field Command Defense Nuclear Agency report FC/09780326 (SFRD) (September 1, 1978).



Standard Distribution

	514114414	Distribute.	
	Copy No.		Copy No.
US DOE, Headquarters Library, Reports Section, Washington, DC	1-3	Commander, Naval Sea Systems Command, Washington, DC	13
Manager, ALO, Albuquerque, New Mexico	4	Director, Air Force Weapons Laboratory,	14
Lawrence Livermore National Laboratory,	5-6	Kirtland AFB, New Mexico	
Livermore, California Sandia National Laboratories, Albuquerque, New Mexico	7	US DOE, Technical Information Center,	15
Military Liaison Committee, Washington, DC	8	Oak Ridge, Tennessee	
Headquarters, Defense Nuclear Agency, Washington, DC		Attn: Weapon Data Index Los Alamos National Laboratory Report Library	16.54
Defense Nuclear Agency Field Command, Kirtland AFB, New Mexico	11-12	Los Alamos National Laboratory Report Library	16-54
	Special I	Distribution	
	Copy No.		Copy No.
US DOE, Headquarters Library, Reports Section	55	Military Liaison Committee	67
Washington, DC	•	Department of Defense	
Attn: COL Charles Steiner. DP-225, GTN		Washington, DC	
		Chairman	
Albuquerque Operations Office Department of Energy	56	Military Liaison Committee	
Albuquerque, New Mexico		Joint Chiefs of Staff	68-69
Attn: Mr. James H. Hines, WDD		Department of Defense	•••
		Washington, DC	
Lawrence Livermore National Laboratory	57-58	Director, Operations	
Livermore, California		Directorate, J-3, OJCS	
Attn: Ralph S. Hager, L 7		Attn: Chief, J-3 REC & MSG BR	
John Stroud, L 6		For: J-5	
Sandia National Laboratories	59-61	Secretary of Defense for Program Analysis and Evaluation	70
Albuquerque. New Mexico		Department of Defense	
Attn: Mail Services Station		Washington, DC	
For: James I. Crowther, Org. 0331		Office of Assistant Secretary of Defense	
Garry S. Brown, Org. 0331		Program Analysis and Evaluation	
W. J. Patterson. Org. 9331		Attn: Charles Pugh/Michael L. Ioffredo	
Sandia National Laboratory	62-63	Secretary of Defense (Atomic Energy)	71-73
Livermore, California	্ব হয়	Department of Defense	
Attn: Document Control	•	Washington, DC	
For: Robert L. Rinne, Org. 8320		Office of the Assistant to the	
Tim P. Tooman. Org. 8324		Secretary of Defense (Atomic Energy) For: Eric Schuld	
Defense Intelligence Agency	64	MAJ Rich Davis	
Department of Defense		Reynaldo Morales	
Washington, DC			
Attn: Allan L. Conner		Secretary of Defense for Research & Engineering Department of Defense	74
Defense Nuclear Agency, Headquarters	65	Washington, DC	
Department of Defense		Under Secretary of Defense for Research & Engineer	ring
Washington, DC			
Attn: MAMR		Office of Deputy Under Secretary of Defense (Policy)	75
For: LtCOL Gary McIntire		Department of Defense Washington, DC	
Defense Nuclear Agency/Field Command KAFB	66	Office of Deputy Under Secretary of Defense (Policy	v)
Department of Defense	30	Attn: Arthur E. Fajans	,,
Kirtland Air Force Base. New Mexico			
Attn: FCSAC, LTC R. Skarupa			





Special Distribution (cont)

	Copy No.		Copy No.
Air Force Weapons Laboratory 96-97 Kirtland Air Force Base, New Mexico Attn: SUL, Ms. Georgiana Hillyer		DET 2. USAFFWS Mountain Home Air Force Base, Idaho	103
For: Report Library		Attn: Nuclear Weapons Instructor	
Eilsworth A. Rolfs		3416th Technical Training Sq/TTV Kirtland Air Force Base, New Mexico	104
Headquarters U. S. Air Force/SAMI	98-100	Commander	
Washington, DC		3416th Technical Training SQ	
Headquarters, U. S. Air Force Chief, Technical Information Service		Attn: Bernard S. Adams/TTV	
AF/SAMI		Headquarters DAMA-AOA-M	105
For: LtCOL Richard A. Harris, XOXFM,	4D-1050	Washington, DC	
COL Ramelo, RDQ-A, 4D-333		Chief, ODCSRDA, Mail Room	
MAJ Nick Hinch, XOXFS, 4D-1018		Headquarters DAMA-AOA-M Attn: MAJ Robert Harter	
Tactical Air Command/LGW Langley Air Force Base, Virginia	101-102		

Commander

Tactical Air Command/LGW
Attn: David E. McCormick

For: XP-ALFA XPBC

